No. 25-1087

IN THE UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

IN RE:

CENTER FOR BIOLOGICAL DIVERSITY, PEOPLE FOR PROTECTING PEACE RIVER, BAYOU CITY WATERKEEPER, HEALTHY GULF, MANASOTA-88, PORTNEUF RESOURCE COUNCIL, RISE ST. JAMES LOUISIANA, SIERRA CLUB, WATERKEEPER ALLIANCE, and WATERKEEPERS FLORIDA,

Petitioners.

APPENDIX OF ATTACHMENTS IN SUPPORT OF PETITION FOR WRIT OF MANDAMUS

VOLUME 1 of 7

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CENTER FOR BIOLOGICAL DIVERSITY, PEOPLE FOR PROTECTING PEACE RIVER, BAYOU CITY WATERKEEPER, HEALTHY GULF, MANASOTA-88, PORTNEUF RESOURCE COUNCIL, RISE ST. JAMES LOUISIANA, SIERRA CLUB, WATERKEEPER ALLIANCE, AND WATERKEEPERS FLORIDA,

Petitioners.

DECLARATION OF SHANNON L. ANSLEY

I, Shannon Leigh Ansley, hereby declare and state under penalty of perjury under the laws of the United States of America that the following facts are true and correct as follows:

1. I make this declaration in support of Petitioner's Petition for Writ of Mandamus. I am over the age of eighteen and competent to make this declaration. The statements made herein are based upon my personal knowledge, opinion, and experience. I am willing to testify under oath.

2. I am a founding member of Portneuf Resource Council and have been active with the organization for approximately 10 years.

3. The Portneuf Resource Council (PRC) is an Idaho non-profit corporation organized in Southeast Idaho and operated out of Pocatello. PRC works to protect and enhance Idaho's unique way of life by empowering residents

to actively facilitate the wellbeing of their communities. PRC advocates for responsible stewardship of Idaho's water, land, air, and natural resources. PRC's primary focus is supporting clean water, clean energy, and responsible management of public lands initiatives in Southeast Idaho.

4. I have a B.S. in geology from the University of Idaho and more than 35 years of working experience as a hydrogeologist. I worked for more than 20 years at the Idaho National Laboratory CERCLA superfund site in Idaho Falls. I also worked for 8 years with the Idaho Department of Environmental Quality with a focus on groundwater protection, including at phosphate mining and associated waste storage facilities. My final stretch of employment was 8 years with the Shoshone-Bannock Tribes, representing the Tribes' interests on phosphate issues, including the Eastern Michaud Flats superfund site.

5. I currently live in Pocatello, Idaho, less than 5 miles away from J.R. Simplot's Don Plant and the associated Eastern Michaud Flats superfund site.

6. I have lived in Pocatello for more than 35 years and am very familiar with the air and water pollution the Don Plant has brought to this region, our communities, and the Shoshone-Bannock Tribes. Unchecked and uninformed growth of residential and educational structures in the City of Chubbuck toward the Eastern Michaud Flats superfund site creates higher risk to vulnerable populations downwind of the gypstack.

7. The Don Plant's historic and ongoing pollution is significant. The Don Plant gypstack was originally constructed directly on the ground with no liner, meaning contaminants such as arsenic, cadmium, lead, mercury, nickel, nitrate, and radionuclides percolated down through the gypstack, into underlying groundwater, and also into surface water of the Portneuf River, immediately adjacent to the Don Plant gypstack. The Environmental Protection Agency (EPA) is acutely aware of the plumes of groundwater under and around the plant contaminated with arsenic, phosphorus, nitrate, and radionuclides, as well as similar contamination in the Portneuf River.

8. There is no end in sight for the Don Plant's groundwater contamination. Despite the Don Plant's operations occurring within an active CERCLA superfund site, EPA recognizes the predicted total phosphorous concentration in the Portneuf River near the facility will remain above the regulatory target in perpetuity with the site's existing remedial activities.

9. The Bureau of Land Management (BLM) has also recognized the Don Plant's pollution in its Record of Decision authorizing a public lands exchange that enables the facility's continued and expanded operations. BLM found past and present actions associated with the Don Plant have resulted in adverse impacts to groundwater and surface water in close proximity to the plant. BLM further recognizes activities at the Don Plant have contributed to the

cumulative degradation and contamination of surface soils, vegetation, and water resources within the Off Plant Operable Unit of the Eastern Michaud Flats Superfund Site.

10. While the Land Exchange is halted due to litigation, BLM's decision to dispose of public lands with historic treaty rights of the Shoshone-Bannock Tribes to J.R. Simplot is an astonishing continuation of our federal agencies' catering to the phosphate industry.

11. In addition to the facility's known polluting operations, the Don Plant has experienced phosphogypsum and process water leaks in 2013, 2015, and 2016, totaling more than 300,000 gallons of gypsum and stack process water released onto Federal lands adjacent to the gypsum stack.

12. The Don Plant has continued to grow and further pollute the air and water near Pocatello despite EPA's piecemeal enforcement actions and the well documented pollution events. A 2016 consent decree documented that fluoride emissions within a 1-to-2-mile radius of the Don Plant are unsafe and require significant reductions. EPA lodged another consent decree last year regarding Simplot's additional violations, this time including failure to report releases of hazardous substances in violation of CERCLA.

13. EPA's enforcement actions have proven woefully inadequate to mitigate the Don Plant's threats to human health and the environment.

14. The Don Plant's underregulated operations negatively impact both my personal interests and the organizational goals of PRC. The EPA's ongoing delay in responding to petitioners' rulemaking petition exacerbates this harm.

Executed on this 2 day of March 2025, in Pocatello, Idaho.

Shannon L. Ansley

No. 25-1087

IN THE UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

IN RE:
CENTER FOR BIOLOGICAL DIVERSITY, PEOPLE FOR PROTECTING PEACE RIVER, BAYOU CITY WATERKEEPER, HEALTHY GULF, MANASOTA-88, PORTNEUF RESOURCE COUNCIL, RISE ST. JAMES LOUISIANA, SIERRA CLUB, WATERKEEPER ALLIANCE, and WATERKEEPERS FLORIDA,
Petitioners.

DECLARATION OF KIRA BARRERA

I, Kira Barrera, hereby declare and state under penalty of perjury under the laws of the United States of America that the following facts are true and correct as follows:

1. I make this declaration in support of Petitioner's Petition for Writ of Mandamus. I am over the age of eighteen and competent to make this declaration. The statements made herein are based upon my personal knowledge, opinion, and experience. I am willing to testify under oath.

2. I live and work in St. Petersburg, Florida in Tampa Bay.

3. I have been employed as an environmental scientist and special projects coordinator for the City of St. Petersburg Water Resources Department since 2018.

4. I have previously worked at the National Oceanic and Atmospheric Association's National Marine Fisheries Service in the Habitat Conservation Division as a Hollings Scholar from 2009-2012, and at the U.S. Geological Survey at the Coastal Marine Science Center as a physical scientist from 2013-2018.

5. I hold a Bachelor of Science and a Master of Science in Environmental Science and Policy from the University of South Florida - St. Petersburg.

6. I have been a volunteer leader for the Suncoast Chapter of the Sierra Club since 2009, serving in various leadership positions. I am currently the Conservation Committee Chair and an Outings Leader. As an Outings Leader, I organize and lead outdoor activities such as hikes, bicycle tours, paddles and other water-based activities, cleanups, and tours of solid waste and recycling facilities. These not only promote environmental awareness but also foster a sense of community among members and awareness about social and racial inequities in our city's history.

7. I am actively involved in Sierra Club campaigns and advocacy efforts, particularly those focused on environmental conservation and public health. I have a lot of contact with the membership through these activities and other events, which keeps me informed about their concerns and priorities regarding

environmental issues. Suncoast Sierra Club has roughly 4,000 local members in Pinellas County and western Pasco County, Florida.

8. As a member of the Sierra Club, I rely on the organization to represent my interests through conservation and advocacy efforts, including legal advocacy, concerning environmental issues such as phosphogypsum and process wastewater regulation. I have participated in many of Sierra Club's activities, including organizing events and speaking at public forums on behalf of Sierra Club.

9. I testified in front of EPA April, 14, 2010 on behalf of Sierra Club regarding seasonal fertilizer bans. (chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://archive.epa.gov/water/archive/web/pdf/tampa2.pdf)

10. My primary concerns about phosphogypsum and process wastewater stem from the lack of proper regulation and their proximity to waterways. These materials pose significant risks to water quality, leading to cascading effects on both the aquatic environment and human health.

11. I have witnessed the impacts of these dangerous wastes firsthand, including the extensive fish kill event resulting from the major release from the Piney Point phosphogypsum stack in 2021. This was the most significant red tide event and fish kill I have seen in my 20-year career as a scientist and as a lifetime resident of Tampa Bay.

12. The Piney Point phosphogypsum stack is located at an abandoned former fertilizer facility in southern Tampa Bay. Facility owners and operators, among them the State of Florida, have mismanaged the site for decades. In March of 2021, a liner tear in one of the process wastewater ponds caused pressurized process wastewater to move through the liner into the phosphogypsum stack below, which breached a retaining wall, threatening the structural stability of the stack. In response, the Florida Department of Environmental Protection (FDEP) authorized the release, via pipeline, of 215 million gallons of contaminated process wastewater into Tampa Bay. That amount of process wastewater contained approximately 200 tons of nitrogen, which fuels harmful red tide blooms.

13. The bloom that followed the Piney Point discharge was so long and so widespread into areas never impacted by red tide before. I looked at the regional water quality monitoring data for this event, where the Piney Point discharge water quality parameters and phytoplankton were outside normal or baseline conditions compared to long-term monitoring.

14. The Piney Point disaster of 2021 led to approximately 1,500 tons of dead fish being collected in Tampa Bay. This had a profound impact on me, both personally and professionally. It was just devastating to me to see the extent of the pollution and its effects on the environment that I have worked so hard to protect. I have dedicated my career and my personal life trying to advocate for and improve

our water quality here in in Tampa Bay and the Gulf of Mexico, and to know that much pollution was just there ready to dumped in the first place was horrifying.

15. The disaster also negatively affected my job at the City of St. Petersburg. I was unable to hold outdoor meetings due to the smell of red tide, which coincided with the COVID-19 pandemic. I could detect the smell and the irritating toxins from as far as three miles inland. I don't suffer from asthma or allergies, yet I was still unable to be outside because of my burning eyes and throat, shortness of breath, nausea from the rotten decay. This made it difficult to conduct necessary work and community engagements safely outdoors, which was standard practice during the pandemic when working indoors in close proximity was also unsafe.

16. The Piney Point disaster impacted not only the environment but also the city's ability to maintain regular services. Many of the city's operations staff were pulled off their regular positions to participate in dead fish recovery efforts. This diversion of resources had a significant economic impact on the city. During the cleanup, city residents, including myself, experienced delays in trash and recycling pickup and responses to water service requests. As a citizen, it was frustrating to see essential services disrupted due to the resources being diverted to address the spill from a private company.

17. I am also deeply concerned for my coworkers who had to clean up the dead fish. They wore masks and gloves, but even then, they were exposed to red tide toxins and had difficulty breathing, while the long-term consequences, including neurological, remain to be seen. The task was depressing, and I could tell it took a toll on their well-being. My coworkers tasked with cleaning up dead fish were often able to do shorter shifts, but the situation was still challenging.

18. Once the fish kills started, the city marketing department quickly created a map on the city's website where residents could report where exactly fish kills were happening. And dead fish were piling up everywhere, and the city would dispatch city staff out to try to address. But there was a long, long waiting list. It was really crazy. The city also had to hire contractors and boats for the cleanup, which likely strained the general fund and affected the city's budget and its ability to provide other services.

19. I am particularly worried about the subsistence fishermen in our community who rely on local fish to supplement their diet and can't afford alternative sources of food. The contamination of fish due to process wastewater spills and discharges, along with other environmental pollutants, poses a direct threat to their health and well-being.

20. In response to the Piney Point disaster, I worked with the Sierra Club in partnership with Suncoast Surfrider to organize the Rally Against Red Tide, a

well-attended march we organized in just 36 hours that the Tampa Bay Times covered aimed at raising awareness and demanding action to address the red tide event caused by the discharge. We had a kayak outfitter, a restaurant owner, a fisherman, and a local gallery owner as speakers.

21. Additionally, Sierra Club hosted a Piney Point forum on World Oceans Day in 2021, which had the highest turnout of any event we've held in years, and featured speakers such as the director of utilities from Pinellas County, the assistant director of the Tampa Bay Estuary Program, and the leader of harmful algal bloom research at the FWC. The event was so popular that we ran out of space at the venue and had to turn people away. People were outraged and desperate for the information and answers they were not getting from any federal officials about this catastrophic event of national scale and importance.

22. I typically spend time outdoors every day, biking, walking my dog, swimming, kayaking and paddle boarding, fishing and boating. I regularly enjoy seeing a variety of wildlife from sea and shorebirds to otters, marine mammals and even sea turtles. I usually lead 6-8 outings per year for Sierra Club in and around Tampa Bay. Following the Piney Point discharge, I was unable to spend any time outside at all, even letting my dog out in my yard was unpleasant and uncomfortable. Sierra Club cancelled planning paddling outings at Emerson Point, Robinson, Shell Key and Weedon Island Preserves, as well as a hike at Terra Ceia

Preserve and birding outing at Fort DeSoto. Personal plans were also impacted. My family usually celebrates Father's Day with a boat rental, sunset and dinner at a restaurant on the beach, but we opted for inland indoor alternatives. With the Bay not experiencing red tide and fish kills this year I'm so grateful to be able to bike to work, walk my dog and watch sunsets at the park. I've already led 4 outings, including a paddle for World Ocean's Day. I've hosted a bachelorette party for one of my best friends on St. Pete Beach, boated from Madeira Beach to Passage Key, took a group of friends paddling on the Chassahowitzka and paddled out in Tampa Bay of Lassing Park with friends to watch the 4th of July fireworks. Last year I created the St. Pete Pelican Scavenger Hunt to be a fun, free activity for people to spend time outside exploring St. Pete, celebrate our City bird, support local business, learn a little, and see a lot of art. Spending time outdoors in Tampa Bay is one of the most important aspects of my life and a main reason for me choosing to continue to live in this area.

23. I am deeply concerned about the radiation exposure risks associated with phosphogypsum stacks. These stacks contain radioactive materials, including radium-226, which decays into radon gas, a known carcinogen. The lack of a comprehensive federal plan for these wastes is alarming, and proposals to reuse or distribute them further into the environment are particularly concerning.

24. Climate change exacerbates the risks associated with phosphogypsum stacks. Sea level rise, changing weather patterns, and extreme weather events all pose threats to the stability and safety of these stacks. The base of the Piney Point phosphogypsum stack is 10 feet above sea level, and a phosphogypsum stack at the Riverview facility is located right on the water's edge in Tampa Bay, one of the most hurricane vulnerable areas in the nation. The current regulatory framework and climate change policies in Florida are insufficient to address these challenges and ensure resilience against projected climate change impacts. With the state of Florida refusing to do so, we need the EPA to step in so that climate change impacts are meaningfully considered during phosphogypsum stack management decision-making.

25. The use of Underground Injection Control (UIC) wells for toxic process wastewater disposal adds another layer of risk, especially when considering that this waste has the characteristics of hazardous waste but just isn't named or regulated that way. The potential for contamination of the aquifer and subsequent impacts on drinking water supplies is alarming, especially given Florida's karst geology and interconnected aquifers.

26. As a lifelong resident of Florida, I have paddled the entire Suwannee River and most of the Santa Fe River. The residents in these areas, along with local

members of the Sierra Club, are incredibly concerned about the impacts of phosphate mining and the inadequacy of remediation efforts by the industry.

27. Recently, I have been looking for property in North Florida, specifically along the Suwannee River as I have long wanted to live there. However, I am very concerned about the impacts of phosphate mining and phosphogypsum disposal in the area, which is Florida's second phosphate producing district in addition to Bone Valley, the nation's largest. The residents in the North Florida region along the Suwanee River, along with our Sierra Club members, do not trust the fertilizer companies and the adequacy of their remediation and reclamation efforts, which are often just a joke when one mining facility is shut down, only for another to open. This has given me pause about buying property there and living in the area, despite my love for it.

28. That process wastewater is now being disposed in injection wells despite the connectivity of our aquifers further exacerbate my concerns about moving to North Florida where there are several springs and also phosphogypsum stacks. I did my master's research on Florida's springs and how they are already becoming more and more acidic, increasing the dissolution of the carbonate platform, decreasing pH in estuarine and coastal environments and increasing CO_2 flux. And so I wonder about the connection between wastewater disposal through

deep injection wells, and whether acidifying springs in the future can really be attributed solely to climate change, over-pumping and a lack of residence time.

29. Some of these industrial pollutants disposed in UIC wells could spread through leaks, migration, and then travel great distances through fast-moving conduits into other areas. I do not trust poorly-supported assertions that the geological formations serving as the wells are completely confined.

30. I have significant concerns about the effectiveness of local fertilizer ordinances that take time and effort to convince local governments to enact, when an industrial polluter can counteract the benefit with one large pollution event, let alone the multiple pollution disasters that do occur. While these ordinances aim to reduce nutrient pollution, the impact of individual actions, such as refraining from using fertilizers, is entirely undermined and irrelevant when regulators allow a corporate polluter to negate all those efforts in one fell swoop. It makes my volunteer work that I am so passionate about much harder, and it's demoralizing. It is hard to tell people not to water with reclaimed water and not to use fertilizer, and it feels just so pointless to try to put it on the individual, when you have an industry and state regulators that display wanton disregard for environmental and human health.

31. It feels futile to encourage individuals to make environmentally conscious choices when large-scale industrial practices continue to cause

substantial harm. This disconnect between individual responsibility and corporate accountability is frustrating and disheartening.

32. For these reasons, I believe federal oversight and specific federal regulations governing waste management at phosphogypsum stacks are crucial to preventing further harm to the environment and protecting public health. The EPA must start by at least answering the 2021 petition for rulemaking. This is a problem that will not go away, and ignoring it is not an option.

Executed on this 6th day of March, 2025 in Pinellas County, Florida.

Kira Barrera

No. 25-1087

IN THE UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

IN RE:
CENTER FOR BIOLOGICAL DIVERSITY, PEOPLE FOR PROTECTING PEACE RIVER, BAYOU CITY WATERKEEPER, HEALTHY GULF, MANASOTA-88, PORTNEUF RESOURCE COUNCIL, RISE ST. JAMES LOUISIANA, SIERRA CLUB, WATERKEEPER ALLIANCE, and WATERKEEPERS FLORIDA,
Petitioners.

DECLARATION OF MARTHA COLLINS

I, Martha Collins, hereby declare and state under penalty of perjury under the laws of the United States of America that the following facts are true and correct to the best of my knowledge:

1. I make this declaration in support of Petitioners' Petition for Writ of Mandamus. I am over the age of eighteen and competent to make this declaration. The statements made herein are based upon my personal knowledge, opinion, and experience. I am willing to testify under oath.

2. I currently serve as the executive director of Healthy Gulf. I have served on the board of directors for the organization since 2016. I have a bachelor's degree in psychology from Tulane University. I have a Juris Doctorate

from Seattle University and a master's degree in environmental law and policy from Vermont Law School.

3. Prior to joining Healthy Gulf, I operated my own private practice for more than 20 years, focusing on public interest environmental and land use law. My practice centered on endangered species, ocean and coastal law, climate adaptation, and water quality issues. I fought for sustainable planning and was honored to represent clients in the public interest.

4. Healthy Gulf is a 501(c)(3) environmental non-profit focused on a just transition that moves us away from extractive systems of energy production, consumption, and political oppression, and towards resilient, regenerative and equitable economies.

5. Healthy Gulf's mission centers on protecting water quality in the Gulf of Mexico. From Texas to Florida, Healthy Gulf endeavors to bring the Gulf of Mexico back from various pollution sources, including expanding phosphate mining and associated waste storage.

6. Improper regulation and storage of phosphogypsum and process wastewater is a huge threat to Healthy Gulf's mission. Many phosphogypsum stack systems are situated directly next to the water's edge and threaten important Gulf estuaries.

7. I have lived in the Tampa Bay region for more than 20 years and feel as though the Gulf of Mexico is my "church." From New Orleans to Marco Island, the Gulf has always felt like a place of refuge and peace for me. I am constantly out on the water and feel that we have a moral obligation to preserve water quality in the Gulf and to protect the species that rely on it.

8. Since moving to the Tampa Bay area in 1998, the Piney Point phosphate facility has been a constant threat to our ecosystems and communities. Improper regulation of this facility harms Healthy Gulf's organizational mission and my personal interests.

9. Every hurricane season, there was the looming fear that Piney Point would not withstand even a glancing blow from a major storm. We were constantly watching the water levels and wondering what type of destruction we could possibly be facing. I never thought that more than twenty years after I first learned of the problematic facility the governor would be evacuating more than 300 homes due to a fear that the gypstack would completely fail.

10. I lived only a few blocks from the water in Tampa Bay when the 2021 discharge occurred. Once the nitrogen inundation from the Piney Point fueled the red tide, I could smell the death and decay of marine life from my property. Enjoying our neighborhood, walking along the water's edge, swimming, and boating are my families past times in the summer and most certainly provided a

place of refuge for us during Covid quarantine. In addition to the stress from Covid; the smell, physical irritants, and mental toll of viewing the marine carnage became so bad we chose to leave our home for several weeks that Summer.

11. The most frustrating part of Piney Point's legacy is that it was allowed to go unpermitted for 20 years before the latest release. So much amazing work was done in Tampa Bay to rebound the seagrasses and biodiversity over the last few decades. Tampa Bay was a success story for bringing an estuary back from the brink, yet industry greed and poor agency regulation destroyed that progress in one fell swoop.

12. The wrongs from Piney Point's release can never be righted. We cannot possibly compensate the fishermen who were unable to work that season, the kids who were unable to spend time on the water, or the families who were forced to evacuate or chose to leave to avoid the stench of death at their doorstep.

13. Unfortunately, nothing has changed in the wake of the Piney Point tragedy. Despite pledging to re-evaluate the Bevill determination over time if existing regulations proved ineffective, regulations have not increased, and the phosphate industry continues to expand at an alarming pace. Known polluting sites such as the Uncle Sam plant in St. James Parish, Louisiana, and the New Wales plant in Mulberry, Florida, are poised to expand despite decades of environmental contamination. Additionally, several Mosaic facilities in Florida have applied to

inject this hazardous waste underground, an action that would be prohibited in the state but-for the Bevill determination.

14. Regulations must change to preserve human health and the environment, and that is exactly what conservation organizations have requested in our February 2021 petition. EPA must live up to its goal to specifically regulate harmful fertilizer production wastes.

15. The EPA's failure to respond to conservation organizations' rulemaking petition further harms my personal interests and the organizational goals of Healthy Gulf. It is paramount that the EPA provide a response to petitioners. The threats to human health and the environment from this waste are too great to continue to ignore.

Executed on this 7th day of March 2025, in Saint Petersburg, Florida.

Martha Collins

No. 25-1087

IN THE UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

IN RE:
CENTER FOR BIOLOGICAL DIVERSITY, PEOPLE FOR PROTECTING PEACE RIVER, BAYOU CITY WATERKEEPER, HEALTHY GULF, MANASOTA-88, PORTNEUF RESOURCE COUNCIL, RISE ST. JAMES LOUISIANA, SIERRA CLUB, WATERKEEPER ALLIANCE, and WATERKEEPERS FLORIDA,
Petitioners.

DECLARATION OF SHARON LAVIGNE

I, Sharon Lavigne, hereby declare and state under penalty of perjury under the laws of the United States of America that the following facts are true and correct as follows:

1. I make this declaration in support of Petitioner's Petition for Writ of Mandamus. I am over the age of eighteen and competent to make this declaration. The statements made herein are based upon my personal knowledge, opinion, and experience. I am willing to testify under oath.

2. I am a founding member and the executive director of Rise St. James, based in St. James Parish, Louisiana, in Cancer Alley, where I have lived my entire life.

3. My home is a half-mile from the Mosaic Uncle Sam phosphogypsum stack, which is laterally shifting due to unstable soils. Despite this, the Louisiana

Department of Environmental Quality (LDEQ) has recently approved expansion plans for the Uncle Sam phosphogypsum stack.

4. For years I saw that stack pile there, but didn't really know what it was until I started doing the work with Rise St. James that I'm doing today, fighting for environmental justice.

5. I live in constant fear that the phosphogypsum stack will leak or burst. Every time I drive down Highway 3125 and see it, I think of all the people in my community that would be in big trouble if the stack burst and the process water got all over them and their homes.

6. I am especially concerned for my daughter and grandson, who live on the East Side of the Mississippi near the Uncle Sam stack. My daughter wants to move, but she doesn't have the finances to move.

7. Even when a phosphogypsum stack like the Faustina stack closes, it's still there. Closure doesn't really mean much, because it's never going away. That's the problem. When we allow these things to grow, they're there forever. They're radioactive for at least 1,600 years, which is the half-life for radium-226. All they do is put grass on top. So when we're talking about closed versus active, all anyone really mean is, is it growing? Is it receiving more phosphogypsum? So that's basically the only difference, because they require just as much management when they're closed.

8. I am worried that expanding phosphogypsum stacks may cover undiscovered grave sites of my ancestors. It's a worry to all of us to the people in convent, the people in Saint James, East and West Bank.

9. When hurricanes come, they stay in the area for a while because of climate change. They used to just come and go, but now they stay there for a while, like the last hurricane, Hurricane Ida in 2021. It stayed at my house, tore up my house, tore up everything. It's a matter of time before another hurricane comes and tears up Uncle Sam. It's a worry for all of us here in St. James Parish.

10. I used to eat fish that my friend would catch near Uncle Sam on a canal off the Blind River, before I knew what Uncle Sam was. Once I found out that it was a radioactive waste pile that was moving and leaking, I told him I didn't want anymore fish.

11. It makes me angry to know that it was a farmer, and not a regulator or Mosaic, who noticed the boil that led to the discovery that Uncle Sam was shifting. They don't regulate. They don't check the area often enough to see if something is going on.

12. I have autoimmune hepatitis, which I learned from reading health articles is attributed to living near industrial pollution. And what Mosaic is going to say is, it's the other facilities, not ours. But they're all together. They're all a part of it and

contributing, and they get away with it by pointing the finger at each other. Many other people in my community have cancer, asthma, and other illnesses.

13. I can't rely on my local leaders to protect me when my parish president makes public statements calling Cancer Alley a myth. It is up to the feds to protect us.

14. Maybe local leaders are silent because the industry gives out little tokens locally. When I was teaching at St. James High School, Mosaic would give us things like umbrellas, t-shirts, and sun visors with Mosaic's name on it. They would pay for Christmas dinner on Christmas. I didn't know any better. I used to say, "Oh, that's so nice!" but not knowing they were polluting us in exchange for little trinkets and tokens. I still have that sun visor from Mosaic. I was ashamed to have worn it. I was hurt to find out that I was accepting stuff from a company that was polluting us.

15. The fact that LDEQ is allowing Uncle Sam to expand despite the risk and instability makes me feel like these people don't live here in Saint James. They don't care if we die. They don't care if we get sick, and they don't care if the thing bursts and goes on to people and kills the people. They don't care.

Executed on this 4th day of March 2025, in St. James Parish, Louisiana.

DocuSigned by:
Sharon Lavigne
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Sharon Lavigne

No. 25-1087

IN THE UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

IN RE:

CENTER FOR BIOLOGICAL DIVERSITY, PEOPLE FOR PROTECTING PEACE RIVER, MANASOTA-88, RISE ST. JAMES, PORTNEUF RESOURCE COUNCIL, OUR SANTA FE RIVER, HEALTHY GULF, WATERKEEPERS FLORIDA, BAYOU CITY WATERKEEPER, WATERKEEPER ALLIANCE, and SIERRA CLUB,

Petitioners.

DECLARATION OF DANIEL E. ESTRIN

I, Daniel E. Estrin, hereby declare and state under penalty of perjury under the laws of the United States of America that the following facts are true and correct to the best of my knowledge:

1. I make this declaration in support of Petitioners' Petition for Writ of Mandamus. I am over the age of eighteen and competent to make this declaration. The statements made herein are based upon my personal knowledge, opinion, and experience. I am willing to testify under oath.

2. I am the General Counsel and Legal Director of Waterkeeper Alliance, Inc. ("Waterkeeper"), one of the Plaintiffs herein. I have held my current position for more than nine years and have worked with the Waterkeeper movement in various capacities for more than 30 years. As Waterkeeper's General Counsel and Legal Director, I am responsible for supervising Waterkeeper's legal

work, including all litigation to which Waterkeeper is a party. In addition to my position as a Waterkeeper executive staff member, I am also an individual supporting member of Waterkeeper.

3. Waterkeeper is a not-for-profit membership corporation organized under the laws of the State of New York and is recognized by the Internal Revenue Service as a charitable corporation under section 501(c)(3) of the Internal Revenue Code. Waterkeeper maintains its headquarters at 180 Maiden Lane, Suite 603, New York, New York 10038. We are a global movement of on-the-water advocates who patrol and protect nearly 6 million square miles of rivers, streams, and coastlines in North and South America, Europe, Australia, Asia, and Africa. Waterkeeper seeks to protect water quality in every major watershed around the world, and to restore and maintain all waterways as drinkable, fishable, and swimmable, consistent with the goals of the federal Clean Water Act and other environmental laws. Waterkeeper works toward this vision through direct advocacy and through the grassroots advocacy of its Waterkeeper member and affiliate organizations, which Waterkeeper connects and supports to provide a voice for waterways and their ecosystems and communities worldwide.

4. Waterkeeper has two classes of members – licensed organizational members and individual supporting members. Waterkeeper's Board of Directors must approve all organizational members for licensure. Once approved and

licensed, member organizations are entitled to vote, through a designated representative, on matters at membership meetings. Among other requirements, member organizations must conform to Waterkeeper's Quality Standards, participate in membership meetings, directly elect one of Waterkeeper's Board members, and elect the Waterkeeper Council, which is composed of more than 20-member organization representatives. Member organizations, through their elected and designated representatives, elect more than half of Waterkeeper's Board of Directors.

5. Waterkeeper currently connects 259 Waterkeeper member organizations and 43 affiliate organizations in 47 countries on six continents, including 146 member organizations and 14 affiliate organizations licensed by Waterkeeper in the United States (collectively, "U.S. Waterkeeper groups"). Co-Petitioner Waterkeepers Florida is a licensed Waterkeeper member organization and is itself composed of 15 other licensed Waterkeeper member organizations. Co-Petitioner Bayou City Waterkeeper is also a licensed Waterkeeper member organization.

6. Our U.S. Waterkeeper groups cumulatively have hundreds of thousands of individual members and supporters that live, work, and recreate on waterways and in watersheds across the United States whose interests are adversely impacted and injured by water pollution, environmental degradation, and adverse

impacts to ecosystems, endangered and threatened species, and their habitats. Each U.S. Waterkeeper group is committed to protecting a specific watershed or waterway. They combine firsthand knowledge of their local watersheds with an unwavering commitment to the rights of their communities. Their work includes water quality monitoring, taking enforcement action against polluters, advocating for stronger water and ecosystem protections before legislative and regulatory bodies and judicial tribunals, and educating and engaging with the public.

7. Waterkeeper supports its U.S. Waterkeeper groups, and their individual members, through coordinated litigation and other advocacy, as well as by providing a centralized hub for sharing scientific, legal, and administrative resources with these organizations across the country; by expanding local Waterkeepers' ability to positively affect environmental compliance and policy on a national level; by sponsoring educational and capacity-building programs; and by providing legal support to these organizations.

8. The second class of Waterkeeper members is composed of over 15,000 individual supporters, of which I am one, who assist Waterkeeper through financial contributions, volunteering, and other vital services. Waterkeeper supports these individual supporting members by advocating on behalf of their environmental, recreational, aesthetic, and other interests in local and national fora, including before legislative bodies, government agencies, and courts of law, and by

keeping them informed about environmental issues that impact their waterways, ecosystems, and communities. Waterkeeper's individual supporting members reside throughout the country, with many members living, visiting, and recreating near various phosphate mines and associated waste facilities.

9. Waterkeeper seeks to reduce and prevent pollution, to protect water quality and availability in every major watershed around the world, and to restore and maintain all waterways as drinkable, fishable, and swimmable consistent with the goals of the federal Clean Water Act ("CWA"), the Resource Conservation and Recovery Act ("RCRA"), and other environmental laws. The CWA is the bedrock of Waterkeeper's work in the United States to protect rivers, streams, channels, lakes, reservoirs, wetlands, bays, estuaries, and coastal waters for the benefit of their communities and ecosystems. In addition to the CWA, Waterkeeper also regularly utilizes and relies upon other environmental statutes to achieve our mission, such as the Endangered Species Act ("ESA") and RCRA. These federal laws are incredibly important because, among other vital attributes, they set limits to manage nutrient inundation into our waterways and determine how mining wastes are managed.

10. For many years, Waterkeeper, U.S. Waterkeeper groups, and our respective individual members have relied on the CWA and RCRA to protect and preserve our watersheds, and several U.S. Waterkeeper groups have actively

worked to fight against regulatory loopholes and lack of federal oversight.

11. Poor regulation of the phosphate industry continues to undermine Waterkeeper's mission for clean water. For example, the 2021 Piney Point discharge followed a decade of the facility operating without a lawfully issued CWA National Pollutant Discharge Elimination System permit. Following the damage to Tampa Bay and associated waterways from the 180 metric tons of nitrogen released in 2021, the Piney Point facility now threatens the Floridan aquifer. Millions of gallons of remaining process wastewater at the facility are currently being injected into an underground injection well in Manatee County that is not designed for injection of hazardous substances. Moreover, the Mosaic Company currently has several pending applications contemplating injection of process wastewater in wells at its New Wales, Bartow, Riverview, and Plant City facilities. These actions would be legally prohibited but-for the Bevill Determination, as the state of Florida does not allow disposal of hazardous waste into injection wells. Given that more than 1 billion tons of phosphogypsum are stored at facilities across the state of Florida alone, the potential for the phosphate industry to continue taking advantage of this regulatory loophole while threatening Florida's water quality is enormous.

12. The EPA's more than 30-year-old regulatory determination exempting phosphogypsum and process wastewater from hazardous waste

regulation does not change EPA's recognition that these wastes are characteristically hazardous. Injecting process wastewater into wells not equipped for hazardous waste disposal is antithetical to Waterkeeper's and U.S. Waterkeeper groups' goals, and further highlights the necessity for EPA to fulfill its stated goal to revisit the Bevill Determination if existing regulation is inadequate to protect the environment.

13. Despite the known environmental consequences, the Bevill Determination may have been justified when it was originally made based on the cost of compliance to the industry to properly treat this waste as hazardous under RCRA. But since the determination, the phosphate industry has become increasingly monopolized, with prolific companies such as The Mosaic Company ("Mosaic") now qualifying for Fortune 500 status. Just as the economic justification becomes less persuasive, the environmental consequences have become untenable.

14. I believe the unfettered expansion of the phosphate industry and the lack of meaningful regulation will continue to harm waterways and groundwater resources important to Waterkeeper, U.S. Waterkeeper groups, and our respective individual members and supporters. Facilities with pollution events that garnered international attention are continuously granted expansion requests. For example, Mosaic's New Wales facility has experienced at least four major sinkholes during

its operations, including one in 2016 that caused a waterfall of toxic waste to plummet into the aquifer. This event was covered internationally, including by Al Jazeera and BBC. This causes me great distress and negatively and directly affects my experiences when I visit the natural areas that I love, including Tampa Bay, which I have visited many times, most recently for five days in October 2023. Degradation of water quality following major releases from phosphate waste facilities is not in dispute, yet no meaningful regulatory changes have occurred.

15. I am personally injured by the EPA's continued delay in responding to Co-Petitioners rulemaking petition. A response to the petition is required under the Administrative Procedure Act and RCRA, and could meaningfully begin to address the continued water quality threats posed by these facilities.

Executed this 7th day of March 2025, in New York, New York.

Daniel E. Estrin

No. 25-1087

IN THE UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

IN RE:
CENTER FOR BIOLOGICAL DIVERSITY, PEOPLE FOR PROTECTING PEACE RIVER, BAYOU CITY WATERKEEPER, HEALTHY GULF, MANASOTA-88, PORTNEUF RESOURCE COUNCIL, RISE ST. JAMES LOUISIANA, SIERRA CLUB, WATERKEEPER ALLIANCE, and WATERKEEPERS FLORIDA,
Petitioners.

DECLARATION OF WILLIAM P. MATTURRO

I, William P. Matturro, hereby declare and state under penalty of perjury under the laws of the United States of America that the following facts are true and correct to the best of my knowledge:

1. I make this declaration in support of Petitioners' Petition for Writ of Mandamus. I am over the age of eighteen and competent to make this declaration. The statements made herein are based upon my personal knowledge, opinion, and experience. I am willing to testify under oath.

2. I am a member of Petitioner ManaSota-88. I have worked with ManaSota-88 since the early 1990s but became an official member in 2016. As a member of ManaSota-88, I actively participate in discussions with ManaSota-88's leadership and contribute to policy development and strategizing aimed at addressing environmental issues related to phosphogypsum and process wastewater

management. I also read ManaSota-88 newsletters and engage in advocacy efforts, including attending local government public meetings whenever phosphate mining and processing impacts are on the agenda. I rely upon ManaSota-88 to represent my interests in a variety of forums, including this legal action.

3. I am also a member of Petitioner Center for Biological Diversity, an organization that I joined in 2016. I routinely receive information from the Center about action alerts, events organized by the Center, and details about endangered species and how the Center is working to protect those species. I rely upon the Center to represent my interests in a variety of forums, including this legal action.

4. I hold a law degree from the University of Florida, obtained in 1975, and a bachelor's degree in political science from the University of Notre Dame, obtained in 1968.

5. I am a retired attorney who previously worked for the Florida Department of Environmental Regulation (FDER), which is now the Florida Department of Environmental Protection (FDEP), from 1982-1986 as an attorney in the rules and enforcement departments. I returned to work for FDEP on an "as-needed" contract basis in the 1990s through the early 2000s as a consultant for special projects.

6. I am aware of phosphogypsum stacks, including those at the Piney Point facility, and their mismanagement by Florida officials and others over the past decades.

7. I lived near the Gulf of Mexico in Manatee County from 2016 to 2019. In May 2019, I moved to my current residence in eastern Manatee County to get away from the water, in part due to worsening red tide, which is exacerbated by nutrient loading and pollution discharges. I lived through the red tide bloom of 2018 in coastal Manatee County and often smelled red tide from my home. I experienced respiratory problems during this time.

8. I worked as a volunteer at the Robinson Preserve, a Manatee County nature preserve, from 2016-2018. One of my jobs during the summer of 2018 was to pick up and dispose of dead sea life that had drifted into the preserve because of red tide and was floating in the inlets. The experience was depressing, but I nevertheless felt compelled to participate in the cleanup because of my desire to restore the area to its natural state.

9. I truly enjoy the recreational opportunities and aesthetic beauty afforded to us by Tampa Bay. I used to frequently recreate by canoeing in Tampa Bay's wild areas, where I observed marine and avian wildlife in its natural environment. The frequency in which I canoe in Tampa Bay waters has been limited in the past five years, however, as I moved inland away from the coast following the significant 2018 red tide event. Additionally, my opportunities to get in the water have been lessened by my age, as I am now in my 70s and cannot get out as often as I would like. Nonetheless, I look forward to every opportunity I have to get into the water,

because it is one of the activities from which I obtain great personal satisfaction and enjoyment.

10. I have frequently paddled near the Piney Point phosphogypsum stack due to its proximity to natural areas, such as the Terra Ceia Preserve State Park and Tampa Bay Estuarine Ecosystem Rock Ponds area. I enjoy seeing wildlife, such as birds, and also observing protected species such as manatees and sea turtles. It is my desire that these species flourish and thrive in their natural environment, and not suffer harm due to human-caused events.

11. These waters and wildlife were negatively impacted by the March-April 2021 Piney Point discharge event, which dumped approximately 215 million gallons of untreated wastewater from the gypstack into the environment when the phosphogypsum stack threatened to collapse. I understand that wastewater contained substantial amounts of nitrogen, which contributes to red tide blooms, among other contaminants.

12. My enjoyment of canoeing, birdwatching, and observing wildlife in the areas surrounding Piney Point has been negatively impacted by the Piney Point discharge event and the continued risk of yet another recurrence without federal oversight and specific federal regulations governing waste management at phosphogypsum stacks. These risks directly and negatively affect my aesthetic and recreational enjoyment of the activities I undertake near Piney Point.

13. I had definite plans to canoe near Piney Point during the summer of 2021, which would have been the first time since moving away from the coast that I had the chance to get in the water. I was looking forward to the opportunity to enjoy the natural beauty of Tampa Bay and all its wildlife. Unfortunately, I made the difficult choice to opt out of those plans because of the Piney Point discharge and subsequent red tide event. I simply cannot obtain the same degree of recreational and aesthetic enjoyment of Tampa Bay when the Bay is polluted with dangerous contaminants from Piney Point, which in turn caused or directly precipitated a major red tide event, leaving tens of thousands of fish and other wildlife to perish. I was also concerned about another catastrophic release from the facility.

14. Since 2021, my recreational activities have continued to be hindered by the ongoing issues at Piney Point and the fact that the same regulators in charge during that disaster and prior disasters at the facility are in charge of the clean-up and closure under the same inadequate state regulatory regime that got us into this predicament in the first place. I had hoped to resume canoeing and birdwatching more frequently, but the persistent environmental risks and the health concerns associated with algal blooms have prevented me from doing so. Looking ahead, I remain cautious and hesitant to make concrete recreational plans near Tampa Bay until more substantial remediation and regulatory efforts are made to address the contamination and prevent future discharge events at the Piney Point site.

15. I worry about how exposure to harmful algal blooms like the historic 2021 bloom unnaturally fueled by the Piney Point discharge will impact my health. As mentioned above, I am now in my 70s and understand that red tide and other harmful algal blooms have been linked to dementia, Parkinson's disease, and other disorders that might affect me. Additionally, the smell from red tide events removes any pleasure I could derive from canoeing or birdwatching, as the smell is offensive and nauseating.

16. I have concerns about how future storms may impact the stability of the phosphogypsum stacks at Piney Point and the surrounding communities. Excessive rainfall, strong winds, tornadoes, and hurricanes all pose a threat to the integrity of these stacks. Poor maintenance is also a significant concern, as companies may prioritize production over proper upkeep and storm preparation for the facilities.

17. I specifically recall Hurricane Ian in 2017, which caused me considerable concern due to its potential impact on the Tampa Bay phosphogypsum stacks at the Piney Point and Riverview facilities. Living closer to the coast at that time, I was more directly affected by such events, but every time a hurricane is headed toward the Gulf Coast, I worry about the integrity of the several phosphogypsum stacks there and their ability to withstand the winds, precipitation, and storm surge. Things will only get worse with climate change.

18. I am deeply concerned about the radiation exposure risks associated with phosphogypsum stacks. These stacks contain radioactive materials, including radium-226, which decays into radon gas—a known carcinogen. Living approximately 17 miles from the nearest stack at Piney Point I am worried about the potential health impacts on my family and myself every time I drive past it, particularly in light of the inadequate regulatory measures in place to safeguard against these risks.

19. I am also concerned about the risk of sinkholes underneath phosphogypsum stacks and their potential to contaminate drinking water. The last reported significant sinkhole event at the New Wales facility in 2016 highlighted these dangers. During this period, I participated in Manatee County public meetings, where I voiced my concerns about the inadequacy of the measures in place to prevent such disasters.

20. While volunteering at the Robinson Preserve, I was shocked when I saw a sign for a new nature center there called the Mosaic Nature Center. I found it ironic and somewhat laughable, as Mosaic Fertilizer is a major player in the phosphate industry, which contributes significantly to environmental degradation. This struck me as a classic example of greenwashing, where a company attempts to appear environmentally friendly while continuing harmful practices.

21. This experience of cleaning up a preserve that includes a nature center named after the largest corporation within the very industry that contributed to its degradation reinforced my belief that easily influenced state and local leaders will never adequately regulate this industry without sufficient federal oversight.

22. Not only do our local leaders facilitate the misleading corporate image of environmental responsibility presented to the public, but in their zoning and permitting decision-making related to phosphate fertilizer industry expansion, these leaders themselves are too easily swayed by so-called goodwill donations and the promise of economic development. This promised economic development is temporary at best, and never seems to arrive in a way that benefits the local community. And it comes at an unacceptable cost – the destruction of natural areas and biodiversity.

23. I believe that if the Piney Point site is not properly remediated and maintained as a regulated hazardous waste disposal facility under the Resource Conservation and Recovery Act, it poses a significant risk to the health of the surrounding ecosystems and communities, including mine.

24. I have significant concerns about the use of Underground Injection Control (UIC) wells as part of the closure plan for Piney Point. Instead of dumping wastewater into the Gulf, the closure involves injecting it into the aquifer. This solution, in my view, is an easy way out and fails to address the long-term

environmental risks. The potential for contamination of the aquifer and subsequent impacts on drinking water supplies is alarming. I am also concerned about this practice spreading to other phosphogypsum stacks throughout Florida. The state's geology is active karst and our aquifers are interconnected.

25. Phosphate mining along with fertilizer production that generates phosphogypsum and process wastewater are components of one singular industry, and the increased phosphogypsum generation that the industry seems to be preparing for by applying for stack expansion permits, UIC disposal wells, and road use approvals, does not come without increased mining in areas like eastern Manatee County near where I currently reside. It is difficult to escape the harmful effects of this industry in Florida.

26. I have a moral interest in preserving biodiversity and conserving protected species. I prefer to use the term "animal sovereignty" because it indicates that animals are inherently equal to humans. I believe species impacted by industrial pollution and red tide, including sea turtles, manatees, and smalltooth sawfish, have an inherent right to live. I am equally worried about the terrestrial wildlife, like gopher tortoises, bobcats, and Florida panthers. we will lose to the expanded phosphate strip mining that is inextricably linked to expanded fertilizer operations and phosphogypsum stack expansions.

27. I am frustrated by the lack of response from the EPA to the 2021 petition for rulemaking submitted by ManaSota-88 and other Petitioners, which sought the federal regulation of phosphogypsum and process water as hazardous waste. The continued absence of federal oversight exacerbates my concerns about the ability of state and local governments to effectively regulate the industry, given apparent alignment with industry interests over public welfare. I am deeply concerned about the industry's continued operations while we wait for a response. These operations include phosphogypsum stack expansion plans and attempts to add to the phosphogypsum stack problem additional risky disposal methods like underground injection and use as road base material.

28. The decades-long and ongoing issues at Piney Point directly impact my ability to enjoy the natural environment and recreational activities in and around Tampa Bay. I believe it is crucial to address these issues at Piney Point and other phosphogypsum stacks promptly and definitively to prevent further harm to the environment and to protect public health, and that will only happen with appropriate federal regulation and oversight.

Executed on this 4thday of March 2025, in Manatee County, Florida.

William P. Matturro

William P. Matturro

No. 25-1087

IN THE UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

IN RE:
CENTER FOR BIOLOGICAL DIVERSITY, PEOPLE FOR PROTECTING PEACE RIVER, BAYOU CITY WATERKEEPER, HEALTHY GULF, MANASOTA-88, PORTNEUF RESOURCE COUNCIL, RISE ST. JAMES LOUISIANA, SIERRA CLUB, WATERKEEPER ALLIANCE, and WATERKEEPERS FLORIDA,
Petitioners.

DECLARATION OF ANDRE MELE

I, Andre Mele, hereby declare and state under penalty of perjury under the laws of the United States of America that the following facts are true and correct to the best of my knowledge:

1. I make this Declaration in support of Petitioners' Petition for Writ of Mandamus. This Declaration is based on my personal knowledge and opinion, and I am competent and willing to testify under oath.

2. I have been a member of People for Protecting Peace River (3PR) since 2019. I became a member because I support the organization's mission of protecting the natural and agricultural lands and waterways of interior Florida in the Peace River and Myakka River watersheds by ending the damage caused by phosphate strip mining and phosphatic fertilizer production.

3. I have a bachelor's degree in environmental science and a master's degree in environmental science with a concentration in environmental economics from Bard College. I have been advocating for meaningful regulation of phosphogypsum and process wastewater from phosphoric acid production for eight years now.

4. In addition to my work with 3PR, I also do independent paid environmental consulting work for a law firm in Alabama, and am the president and Waterkeeper of Peace Myakka Waterkeeper, Inc. I was also actively engaged in this issue while I was the executive director and Waterkeeper for Suncoast Waterkeeper from 2016 until 2019.

5. I live in Myakka City, Florida, about 45 minutes south of the phosphogypsum stacks located in Bartow and New Wales, Florida. These stacks use the Peace and Alafia Rivers as industrial sewers, and I have personally observed NPDES outfalls in the Peace River Basin at Bonnie Mine Road and CR 640, Little Payne Creek and S. Fort Meade mine. There is another outfall on Mosaic property at the New Wales facility. Many of the industrial outfalls that Mosaic utilizes go into the Peace River directly or are within the Peace River watershed.

6. The region where I live is known as Bone Valley, an area in central Florida where the majority of phosphate mining in the United States occurs.

7. I live about one mile from the Myakka and ten miles from the Peace River and regularly walk by Morgan Park near the Peace River and take my lunch breaks there. I get recreational and aesthetic enjoyment from participating in activities along and in the Peace River. The Peace River is an important tourism resource, and I am one of the thousands of people who paddle the river every year. I have paddled the Peace River too many times to count, but I estimate I do it between five and ten times per year. I own a canoe and a kayak for this purpose.

8. I have noticed increases in blue-green algae approximately contiguous with the phosphogypsum stacks. Historically, I have observed the shades of green intensify over the past several years, which may be a combination of factors including nutrients from agriculture, wastewater treatment plants, and nitrates from phosphogypsum stack discharges. Mosaic disposes into the Peace River toxic waste that accumulates in phosphogypsum ponds and stormwater ditches on their property. The Florida Department of Environmental Protection ("FDEP") allows this waste to be diluted with freshwater in accordance with their National Pollutant Discharge Elimination System ("NPDES") permit, and only regulates the allowable concentration of toxins in proportion to a given quantity of water that discharges through an outfall. This regulatory methodology does not account for, in any way, the total mass of a given toxin entering the environment. Hence, the total mass of these toxic and hazardous substances from the outfalls flow

downstream unregulated numerically, in greater or lesser quantities depending on overall water flows. This loophole, in my opinion, encourages Mosaic to release larger discharges of hazardous and toxic materials during rain events and high flow periods. Without this loophole, Mosaic would be required, like most heavy industries, to subject their water discharges to municipal standards.

9. The lack of regulation of phosphogypsum as a result of the Bevill exemption is impacting human lives. People have contaminated well-water and are breathing contaminated air. Radioactivity is omnipresent in Bone Valley and the surrounding watersheds, as I have personally observed, and there is no question as to what this radioactivity does to human health and the wildlife. Mined areas have a peculiar, lifeless feel to them.

10. One night while driving by the New Wales facility, I noticed huge clouds of smoke or fog coming from the plant near the phosphogypsum stacks, causing thick smog in the streets of Mulberry. We had the windows rolled down and it seemed like this low-lying fog was acidic. Everyone in the car started coughing and we had to roll the windows up. I just sped through town to get away from the smog as fast as possible. It is concerning to experience this degree of air pollution and the risks to our health.

11. In addition to the inherent risks of air and water pollution that are present just because of the existence of these phosphogypsum stacks, there are also

numerous threats posed by the possibility of storms. Because of Florida's vulnerability to hurricanes, I am also extremely concerned anytime a hurricane or major storm rolls through, which happens every year, if not several times a year. The lakes of toxic and acidic process wastewater that sit atop the phosphogypsum stacks experience wave action that pound away at the berms around the sides of the lake, threatening the structural integrity of the stack. There is always a risk that a powerful storm could cause a partial collapse of one wall of a phosphogypsum stack or the collapse of a berm, resulting in a breach. All of these things seem to happen routinely.

12. With the millions of tons of phosphogypsum produced every year, these toxic mountains are getting higher and higher, and they eventually reach a point where they are not structurally stable anymore. Because of this, FDEP is giving the industry permits to store even more waste. FDEP is allowing lateral and vertical expansion at the New Wales phosphogypusm stack, site of the 2016 sinkhole that allowed 215 million gallons of radioactive water to flow into the Floridan Aquifer—Florida's principal water supply—and the Bartow facility is reactivating an older, closed stack at Green Bay to receive phosphogypsum slurry from the Bartow Chemical Plant. These permits are allowing an enlargement of the already existing, massive, unstable phosphogypsum stacks.

13. There are so many things that have not been studied or explored because of the EPA's Bevill determination, and we need this information. We need the EPA to come back to Florida and regulate phosphogypsum meaningfully at the federal level. I think it would be highly desirable for the EPA to take a more proactive role in the whole phosphate process, and that starts with responding to the 2021 petition for rulemaking.

14. These phosphogypsum stacks need to be treated as the danger to human health and the environment that they truly are. They contain listed toxic wastes such as chromium, cadmium, arsenic, and more. I have done core samples of the sediment at the mouth of Peace River and found deposits of chromium and arsenic.

15. It truly concerns me that the phosphogypsum and process wastewater containing these hazardous substances aren't being regulated as hazardous wastes because of an industry-favoring regulatory loophole. My moral interest and sense of social responsibility is mortally offended that right in my community, there is an industry sending its pollution downstream for other people to deal with. I have worked with many families within Bone Valley, many of them my friends, and there is cancer in virtually every household. To me, this ongoing injustice is akin to the Love Canal disaster.

16. I have read studies demonstrating the risk that phosphogypsum stacks emit smaller particulate sizes of these hazardous substances then are regulated by the Clean Air Act, and travel miles away by wind. These particulates are small enough to enter our lungs and bloodstream, and that really makes me worry about our health.

17. The process wastewater that sits atop the stacks, which I like to call toxic soup, is so acidic that it is only slightly higher than the pH of battery acid. This extremely dangerous and acidic substance is a threat to everyone who lives in Bone Valley, like I do, because on multiple occasions the phosphogypsum stacks have breached and discharged hundreds of millions of gallons downstream. One example is the Mulberry Phosphate disaster in 1997 where 50 to 60 million gallons of this acidic process wastewater spilled into the Alafia River and traveled all the way to Tampa Bay, killing literally all marine life in the Alafia on the way down. These disasters are not uncommon, and those of us who live around and within the watersheds of these stacks are constantly worried about when the next spill will be.

18. Failing to respond to the 2021 Petition continues to harm the communities and wildlife surrounding the phosphogypsum stacks. The EPA needs to respond and take action to protect the people and wildlife located in Bone Valley and all the downstream areas that are clearly impaired by the phosphate industry. There are many communities surrounding the rivers that are receiving

and drinking the polluted wastewater from the phosphate industry, including the Alafia, the Myakka and Peace. These waters, treated to minimum state standards, are supplied by Tampa Water and the Peace River Manasota Regional Water Supply Authority (PRMRWSA) and serve communities in Pasco, Pinellas, Hillsborough, Polk, Manatee, Sarasota, Charlotte and Desoto Counties. PRMRWSA supplies 900,000 customers per day.

19. The pollution from the phosphate industry reaches far beyond Bone Valley, extending all the way down to Tampa Bay and Charlotte Harbor. Given the range of communities impacted by this environmental injustice, the EPA should take a greater interest in ensuring that continued environmental disasters are minimized and protecting our vitally important water resources for future generations.

Executed this 6th day of March, 2025 in Arcadia, Florida.

Andre Mele

No. 25-1087

IN THE UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

IN RE:

CENTER FOR BIOLOGICAL DIVERSITY, PEOPLE FOR PROTECTING PEACE RIVER, BAYOU CITY WATERKEEPER, HEALTHY GULF, MANASOTA-88, PORTNEUF RESOURCE COUNCIL, RISE ST. JAMES LOUISIANA, SIERRA CLUB, WATERKEEPER ALLIANCE, AND WATERKEEPERS FLORIDA,

Petitioners.

DECLARATION OF DUSTIN PACK

I, Dustin Pack, hereby declare and state under penalty of perjury under the laws of the United States of America that the following facts are true and correct to the best of my knowledge:

1. I make this declaration in support of Petitioners' Petition for Writ of Mandamus. I am over the age of eighteen and competent to make this declaration. The statements made herein are based upon my personal knowledge, opinion, and experience. I am willing to testify under oath.

2. I am a member of Tampa Bay Waterkeeper ("TBWK"). I became a member because I support and rely on TBWK's mission to protect, preserve, and improve the waters of Tampa Bay as well as the mission of the Waterkeeper Alliance, of which TBWK is a member organization, to ensure fishable,

swimmable, drinkable clean water for all.

3. In addition to being a member of TBWK, I volunteer as a member of TBWK's board of directors to help effectuate and realize TBWK's mission, which is very important to my moral, spiritual, recreational and aesthetic interests, as well as my professional and economic interests in a clean and healthy Tampa Bay estuary and watershed. I joined the board in December of 2020. To that end, I donate significant amounts of my time on behalf of TBWK to advocate, educate, and fundraise. I engage with media, community leaders, and decisionmakers and share TBWK action alerts, activities, and events within my personal and professional networks. I attend TBWK board meetings and events regularly, and confer with other TBWK members and supporters, other TBWK members, and other members of the Tampa Bay fishing community to better inform my opinions and weigh in on issue prioritization and program development for TBWK. My involvement and membership with TBWK provides me a platform to share my experiences on the water broadly, something I deeply value and see as important to both mission fulfillment and protecting my personal and economic interests.

4. I am a native Floridian and have lived in Tampa Bay since I was four years old. I have been fishing the waters of Tampa Bay for the past 30 years and am a fisherman by both identity and trade.

5. I grew up loving Tampa Bay. I am often awestruck by the diversity

of the estuary, not only how many fish we have but how many different species, and by the sheer size of the estuary and the amount of seagrass clean water we typically have – from fresh, to brackish, to salt – and the opportunities for enjoyment those different types of water and habitats bring. Tampa Bay is one of the largest open water estuaries in the country, and not only from a fishery perspective, but from a wildlife observation standpoint as well, we have almost everything here. From redfish and tarpon, to dolphins, rays, manatees, and birds, we are lucky to have it all.

6. Recreationally, one of my favorite past-times besides fly fishing is birdwatching. Locals often take for granted just how many bird species this estuary supports. My favorite fish is redfish, and my favorite bird is the kingfisher. It distresses me at my core to know Piney Point caused them harm, and phosphate operations will continue to cause them harm if the EPA’s action continues.

7. I do not only value the Tampa Bay estuary because I fish it and get recreational and aesthetic enjoyment from clean water, clean sea breeze and wildlife observation. I believe the estuary and its nonhuman inhabitants have inherent value and derive satisfaction knowing they are there without having to see or experience them. This is their home, not ours, and they do not exist simply for our benefit.

8. I believe it is critically important to have eyes on the water and

spread awareness about what I see, as the general public and decision-makers do not always have a firsthand account of the devastating effects government and industry malfeasance can have on fisheries and the larger ecosystem, particularly in Tampa Bay.

9. I view the 2021 Piney Point discharges into Port Manatee as that year's greatest environmental disaster in Florida if not the country, and one of the greatest environmental disasters impacting water quality in the history of Tampa Bay.

10. It is important to me that Floridians and impacted stakeholders have opportunities to meaningfully engage with and inform environmental protection efforts and enforcement activities that are managed by governmental entities like the Florida Department of Environmental Protection (FDEP) and EPA. Petitioners request under the Resource Conservation and Recovery Act (RCRA) is a great example of the public participation I value, and what was envisioned by Congress.

11. Eight years ago, I started my fly-fishing guide business, Fly Tide Charters, which is my primary source of income.

12. Among the broader angling community, the fly-fishing community is particularly attuned to fishery and ecosystem impacts, and deeply respectful of the fish that make up its fisheries as well as other wildlife. My business focuses on catch-and-release methods, ensuring the fish we see can continue reproducing and

bolstering the population.

13. Fly fishing is niche, and the Tampa Bay fly fishing community is relatively small with only a few guides doing it. At only eight years old, I consider Fly Tide Charters to be a growing business, almost entirely dependent on word of mouth and social media. Every trip counts. One new client could be a client for the next 15 years booking trips, and each new client could lead to multiple other new clients in the future.

14. I first heard of the discharges from Piney Point the day before Easter 2021. My immediate thoughts were about how this could happen and wanting to know why it could happen yet again. I wondered how much the FDEP was going to let go this time. I didn't know just how contaminated the wastewater was, but I knew it was going to be detrimental. I was worried and did not enjoy the holiday, but I had no idea of the full caliber and scale, not only of the amount of the total discharge and contaminant concentration, but also impact.

15. I first saw the fish kills myself on the water beginning in mid-June. There were hundreds of dead catfish and speckled trout floating along Bayshore. I thought, "Oh no. This is it. This is where it starts." I had a sense that it would only get much worse once the water temperature went up and the extra nutrients cycled through the algae. Turns out June was hot enough, and I've never seen anything in my 30 years on the Bay like the red tide bloom and fish kills I witnessed in June

and July of 2021. You could literally see white specks for as long as the eye could see. I literally hoped it was trash and not dead fish. I was wrong. I was surrounded by death and putrid, noxious air. In addition to the lost business, I couldn't enjoy the Bay I love at all. I went from guiding for income and in my spare time fishing and birdwatching on the water to bearing witness to death and destruction on the water.

16. In July of 2021, I saw dead Tarpon on two separate occasions: one in the Old Tampa Bay and another near Davis Island. We also saw dolphin, hammerheads and manatees dead. Once you see a big, impressive fish like a Tarpon dead, you know it is terrible and nothing else has a chance.

17. Fly Tide Charters is busiest during Tarpon season, which is in May, June, and July. Because of the unique, niche nature of fly fishing and my business, we do not book family trips where you can simply move to another area and target another or any type of fish if you can't find what you're looking for in the first. We are specific, and fish what clients booked the trip to fish and in those locations. In June and July, that becomes Tarpon fly fishing near the beaches. The catastrophic red tide event and fish kills caused by the Piney Point disaster completely wiped out my business in July. My first trip that a client canceled was for June 30, 2021. Once the fish kills hit the beaches in early July, it was all over. I did not guide a single trip that month, when I estimate about 15 trips were canceled.

18. Even after Tarpon season, I booked significantly fewer trips than in previous years though my business had been growing due to word-of-mouth each year. My wife and I were forced to rely on other sources of income and our savings that summer.

19. Also in July, I felt I had no choice but to switch gears and share what I was seeing with as many people as possible. I spent the time I would ordinarily spend making money instead on activism and advocacy, screaming from the rooftops to anyone who would listen about what was happening, taking folks on my boat to tour the destruction, and doing media interviews, activities from which I do not earn any income.

20. Every time I hear of new leaks, new expansions of gypstacks, or new underground injection well permits, I think about how big the disaster could be this time. If this continues to happen, we won't have any seagrass and we won't have a Bay as we know it.

21. No regulations changed in the wake of Piney Point. EPA did not step in once it became clear that FDEP has failed to properly act as a regulator. Moreover, EPA refused to step in and classify this waste by its hazardous characteristics. These stacks are a ticking time bomb, and now the underground injection wells are too. Florida does not allow hazardous waste to be injected underground, largely due to the characteristic of the waste, yet EPA's

determination allows this regulatory loophole.

22. In the wake of Piney Point, I hoped that something would change. I hoped that the disaster would wake up our regulators that something *must* change. Yet the phosphate industry continues to expand, and the EPA continues to disregard our organizations petition for change.

23. It would take 10 years to rebound Tampa Bay under perfect conditions, and I am fearful that our regulators will continue to allow it to degrade at the whim of the phosphate industry.

Executed on this 4th day of March 2025, in Tampa, Florida.

/s/ *Dustin Pack*
Dustin Pack

No.

IN THE UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

IN RE:

CENTER FOR BIOLOGICAL DIVERSITY, PEOPLE FOR PROTECTING PEACE RIVER, BAYOU CITY WATERKEEPER, HEALTHY GULF, MANASOTA-88, PORTNEUF RESOURCE COUNCIL, RISE ST. JAMES LOUISIANA, SIERRA CLUB, WATERKEEPER ALLIANCE, AND WATERKEEPERS FLORIDA,

Petitioners.

DECLARATION OF KRISTEN SCHLEMMER

I, Kristen Schlemmer, hereby declare and state under penalty of perjury under the laws of the United States of America that the following facts are true and correct to the best of my knowledge:

1. I make this declaration in support of Petitioner's Petition for Writ of Mandamus. I am over the age of eighteen and competent to make this declaration. The statements made herein are based upon my personal knowledge, opinion, and experience. I am willing to testify under oath.

2. I live in Houston, Texas. Houston is where I was born and grew up, where my husband was born and grew up, where we are raising a child, and where our parents and much of our extended family still live.

3. My home in the Old Sixth Ward Historic District is between two

bayous. My home is half a mile from Buffalo Bayou, in a portion of the bayou that is tidal. I'm a one-mile bike ride away from White Oak Bayou. I regularly walk or bike along both bayous and watch birds. I also kayak along both of these bayous and other waterways across the Lower Galveston Bay watershed, including Buffalo Bayou, Sims Bayou, Brays Bayou, Clear Creek, Robinson Bayou, Armand Bayou, Galveston Bay, and Christmas Bay. I have visited, am familiar with, and have an affinity for many other waterbodies in this region beyond the ones just named.

4. I am the Senior Legal Director and Waterkeeper of the Bayou City Waterkeeper (BCWK) and have been employed by the organization for nearly seven years. BCWK is a Houston-based organization focusing on water quality, wetlands protection, and flood mitigation across our region with an emphasis on climate resilience and environmental justice. An independent 501(c)(3) organization, BCWK has been a licensed Waterkeeper organization and a member of the Waterkeeper Alliance since 2001.

5. BCWK's mission is to protect the waters and people of the greater Houston region through bold legal action, community science, and creative, grassroots policy to further justice, health, and safety for our region. We envision a Houston where water is a catalyst for change. By connecting community, place, policies, and systems we collaboratively advance equitable distributions of power and resources towards life, joy, and regeneration for our watershed.

6. We organize our work around three overlapping program areas: Clean Water, Protecting Wetlands, and Industrial Risks. Most relevant to this litigation, our Clean Water program centers on reducing the greatest sources of water pollution across this region. Our Industrial Risks program centers on reducing risks presented by industrial polluters to local communities, including risks posed by insufficient industrial regulation to low income and minority communities.

7. BCWK's policy agenda names "Reduce industrial risks by closing regulatory gaps and exclusions from environmental review" as a top demand and lists "Update EPA rules for plastics, petrochemical, and fertilizer facilities with stricter effluent guidelines and chemical safety standards" as a measure to meet this demand.

8. BCWK is a founding member of the Coalition for Environment, Equity, and Resilience, a coalition of 28 organizations and community members, formed in the immediate aftermath of Hurricane Harvey in 2018 and collaborating around an 8-point plan. Among the goals under this plan is preventing contaminants from entering local waterways.

9. BCWK is also a member of the Healthy Port Communities Coalition, a coalition of community-led organizations and nonprofit partners working to create a healthier Houston by empowering residents living along the Houston Ship Channel to recognize local issues and advocate for their communities. The

coalition champions chemical safety because no community should live in fear of industrial facilities near their homes. Among our goals is creating a healthier Houston by preventing pollution before it happens.

10. As the Senior Legal Director for BCWK, my work confronts the many facets of water injustice, from water pollution and infrastructure failures to wetlands destruction and flooding, to inequities in climate mitigation and disaster recovery.

11. As the organization’s Waterkeeper, I work collaboratively to set organizational priorities and participated in the creation of our most recent strategic plan.

12. BCWK has more than 4,000 members, supporters, and affiliates who live across the Lower Galveston Bay watershed encompassing the greater Houston region.

13. Through our work, BCWK aims to benefit the approximately 7 million people around the Lower Galveston Bay watershed encompassing the greater Houston region.

14. BCWK’s members include people who live near the Galveston Bay and associated waters; people who fish, swim, and boat on the river and associated waters, and who enjoy viewing or attempting to view the wildlife living in and near the river; and people who get their drinking water from the river. Our members

include disproportionately impacted residents living in communities prone to flooding and/or adversely impacted by industrial pollution, and water, climate, and infrastructure injustices.

15. My work as the BCWK Waterkeeper is shaped by my life growing up in Houston, the years I spent in New Orleans with Hurricane Katrina and Deepwater Horizon explosion as bookends, and the experience of living through disasters in Houston in more recent years, including Hurricane Harvey in 2017, Winter Storm Uri in 2021, and the derecho in 2024. These recurrent storm events highlight the threats posed by mountainous heaps of toxic waste placed directly near valued waterways and vulnerable communities.

16. My understanding of pollution through my work as BCWK Waterkeeper also has changed the way I view not just major storms but the regular rains we face in this region. With industrial waste insufficiently regulated, and incidences of pollution not consistently or fully enforced, I am concerned about water quality in our water-abundant region. This affects how I interact with water, and how I allow my child to interact with water.

17. I am also a Texas Gulf Coast Master Naturalist and am deeply committed to understanding and protecting the ecosystems of this region.

18. Through my work as the Waterkeeper and Sr. Legal Director of Bayou City Waterkeeper, I am aware of pollution in the Lower Galveston Bay

watershed. In particular, I know that the watershed receives a substantial amount of industrial pollution, including historic pollution from the phosphate industry.

19. The Houston area has experienced several major phosphate waste pollution events, including in 1998 and 2007. In January 1998, FKP Inc., discharged more than 6.6 million gallons of wastewater containing ammonia, nitrogen, copper, nickel, fluoride, phosphorous, and sulfate into the Houston Ship Channel on two separate occasions. In August of 2007, failure of a gypstack retaining wall at the Agrifos facility in Pasadena, Texas, caused the release of approximately 54 million gallons of highly acidic process wastewater into Cotton Patch Bayou, which flowed into Houston Ship Channel that connect to the tidal portion of Buffalo Bayou near my home and where I spend time. A major fish kill was reported in the bayou directly thereafter. The following year, EPA issued an order identifying the facility as posing an imminent and substantial endangerment to human health and the environment.

20. In December 2011, the same Agrifos facility was subject to an investigation concerning violations of the Resource Conservation and Recovery Act and Clean Air Act. Among the allegations, EPA claimed Agrifos unlawfully disposed of various hazardous wastes into the gypsum stacks at the facility. Agrifos and EPA entered a Consent Agreement and Final Order on December 11, requiring the company to pay a $1.8 million dollar penalty and to conduct a

supplemental environmental project to resolve the allegations.

21. The FKP and Agrifos pollution events occurred after the 1991 Bevill Determination, in which EPA announced an ongoing obligation to explore strategies to prevent contaminant releases to the environment and potentially revisit the regulatory determination if existing regulations are inadequate.

22. Insufficiently regulated phosphate waste at historic polluters of the Houston Ship Channel and associated waterways undermines broader efforts at reducing environmental pollution and BCWK and our members' interests in environmental justice. Both BCWK, our members, and I are extremely concerned about pollution and storm risks caused by these facilities.

23. The harms and concerns of BCWK, our members, and myself, could be redressed by EPA responding to conservation organizations' rulemaking petition. The requested rulemaking would mitigate the threat of pollution to the Houston Ship Channel and Galveston Bay by potentially eliminating a regulatory loophole allowing facilities to manage characteristically hazardous waste as non-hazardous. It would also hold EPA accountable to its stated obligation to protect human health and the environment from phosphate waste.

Executed on this 6th day of March 2025, in Houston, TX.

Kristen Schlemmer

No.

IN THE UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

IN RE:

CENTER FOR BIOLOGICAL DIVERSITY, PEOPLE FOR PROTECTING PEACE RIVER, BAYOU CITY WATERKEEPER, HEALTHY GULF, MANASOTA-88, PORTNEUF RESOURCE COUNCIL, RISE ST. JAMES LOUISIANA, SIERRA CLUB, WATERKEEPER ALLIANCE, AND WATERKEEPERS FLORIDA,

Petitioners.

DECLARATION OF GALE TEDHAMS

I, Gale Tedhams, hereby declare and state under penalty of perjury under the laws of the United States of America that the following facts are true and correct to the best of my knowledge:

1. I make this declaration in support of Petitioners' Petition for Writ of Mandamus. I am over the age of eighteen and competent to make this declaration. The statements made herein are based upon my personal knowledge, opinion, and experience. I am willing to testify under oath.

2. I have been a member of the Center for Biological Diversity since June of 2021. As a member, I read newsletters, social media posts, and participate in actions such as petition signing or letters to legislators on important topics impacting our community. I rely upon the Center for Biological Diversity to represent my interests in a variety of forums, including legal

action.

3. I currently reside in Holmes Beach, Florida. I moved to the area in October of 2017 but have been coming to this part of Florida for decades. I routinely visited my grandparents' condo in this area in the late 1960s and owned several properties through the years all with the plan to move here for retirement. As a result, I know this area well, and I feel I have a deep connection to the community, the environment, and its wildlife.

4. I was aware of the former Piney Point phosphate facility ("Piney Point") prior to moving to Florida. When I became a full time resident, I started hearing more and more about phosphate mining and the potential for the phosphogypsum stacks at Piney Point to fail. I began monitoring Manatee County commission meetings on this issue and other topics concerning the environment and was appalled that this had gone on for so many years.

5. I enjoy recreating in the waters near and around Piney Point. Being near the gulf and bays around Anna Maria Island is the main point of moving here. My husband and I routinely and frequently participate in water sports around Tampa Bay, as so many Floridians do. We especially enjoy kayaking and paddle boarding. We recreate in the waters around Robinson Preserve, Terra Ceia Aquatic Preserve, Bimini Bay, along the intercoastal water way from Sarasota Bay to Tampa Bay and the Gulf shores of Anna Maria Island.

6. I paddled the waters near Robinson Preserve in the late spring and into summer of 2021 following the massive discharge of toxic waste from Piney Point. The stench from algae growth caused by the Piney Point discharge was unbearable. The water was brown and murky and looked terrible, with mats floating in the water and collected on the shoreline. My enjoyment of this paddle was dramatically reduced due to the smell and other negative impacts of the bloom. I was very worried about the health of the bay as well as the bacteria build up that was sure to come.

7. The red tide bloom started soon after, fueled by the nutrient loading from Piney Point's discharge. You can tell red tide in the air by a tickle in the back of your throat. We were forced to greatly limit our walks on the beach or had to wear a mask to protect ourselves. My husband and I were forced to keep our windows closed at home during the red tide events because the irritation and coughing was overwhelming. This greatly reduced the pleasure of living close to the Gulf.

8. In the summer of 2021 we struggled with dead fish on the beach and had to carefully pick days to paddle or walk the beach to avoid the smell of red tide and decay. The offending odors from the red tide were noxious and I worried that being out paddling or walking the beach would be dangerous to my health.

9. Outside of recreation, I have interests in protecting seabirds,

turtles, and other marine wildlife. I have volunteered with a turtle watch organization that works to protect Tampa Bay's sea turtle populations. Knowing that the 2021 red tide event injured sea turtles, which was precipitated by the discharges from Piney Point, caused me great distress. I am also very concerned about seabirds. I enjoy viewing seabirds in the wild but knowing that these birds are imperiled by corporate pollution like that from Piney Point is sad and frustrating as many are already threatened or endangered. Poor water quality driven by the Piney Point discharges impacts every facet of the Tampa Bay ecosystem, including harm to several threatened and endangered species.

10. The red tide and poor water quality affected many other species, including horseshoe crabs. I was a volunteer surveyor and data collector with the Florida Fish and Wildlife Conservation Commission for horseshoe crab counts and coordinator for the Robinson Preserve area in 2021. On November 3, 2021, I counted 88 dead horseshoe crabs in an approximately 150 yard stretch along the bay. I attribute this appalling number of deaths to the red tide that persisted through October 2021.

11. I also volunteer for a wildlife rescue and rehabilitation organization called Wildlife Inc. My heart aches when I see seabirds coming into our facility, starving, sick, and knowing that the water quality impacts from pollution like that at Piney Point has caused these problems. Many of these

seabirds do not survive. Into 2022, we were still getting sick sea birds from Anna Maria Island and the west coast of Bradenton from the red tide of 2021 -- pelicans, cormorants, terns, gulls and anhingas that are threatened by poor water quality and impact on their food chain.

12. During the summer and when the red tide was at its peak, I refrained from walking the beach due to worries about exposure to the toxins of red tide. I am worried about my health now, as the red tide is something I could taste in my throat and information as to the impact on humans is not well known. I do not derive any enjoyment knowing that my health could be injured by simply walking on the beach. Likewise, I haven't been able to enjoy swimming in the water, because I fear that being in and around the water during and following a red tide event will cause injuries to my health. I also have allergies and mild asthma, both of which are drastically exacerbated during a red tide event like that of 2021.

13. I had definite plans to frequently paddle in the waters near Piney Point the summer of 2021, but many times did not follow through on those plans due to the concerns outlined above. There is no enjoyment paddling in polluted waters that threaten my health and the wildlife that I cherish.

14. We continue to paddle the intercoastal waterways and inside Tampa Bay nearly once a week. We also walk the beaches of north Anna Maria Island three or four times a week, mostly looking for turtle nests and

other wildlife. The red-tide may have ceased, but the impacts to water quality from Piney Point are far from over. It will take years for Tampa Bay to recover from the massive nutrient inundation it received during the Piney Point discharge.

15. I worry that the poor patchwork of state and federal regulation allows these stack systems to continue threatening the health of Tampa Bay and surrounding waters.

16. It is disturbing that no regulatory changes took place in the wake of the 2021 Piney Point discharge. This should have served as a wake-up call to state and federal regulators that this industry needs more oversight.

17. The devastating Piney Point release occurred more than a decade after the Clean Water Act permit for the site expired, and state regulators continue to allow industry expansion within the state. These stack systems have posed threats to Floridians, our wildlife, and water quality for far too long.

18. My sincere hope is that this lawsuit begins to rectify the problems at phosphogypsum stack systems by instigating meaningful regulation of this industry. The Environmental Protection Agency's delay is unacceptable given the past and present harm to ecosystems and human health from phosphate waste. With looming threats of climate change and sea-level rise, these stack systems are ticking time bombs without proper regulation and oversight.

Executed on this 4th day of March 2025 in Holmes Beach, Florida.

Gale Tedhams

Gale Tedhams

Via Certified Mail/Return Receipt Requested and E-mail

February 8, 2021

Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW #1101A
Washington, D.C. 20460
Regan.Michael@epa.gov

Re: Petition for Rulemaking Pursuant to Section 7004(A) of the Resource Conservation and Recovery Act; Section 21 of the Toxic Substances Control Act; and Section 553 of the Administrative Procedure Act Concerning the Regulation of Phosphogypsum and Process Wastewater from Phosphoric Acid Production.

Dear Administrator:

Please accept the enclosed petition from People for Protecting Peace River, Atchafalaya Basinkeeper, Bayou City Waterkeeper, Calusa Waterkeeper, Center for Biological Diversity, Cherokee Concerned Citizens, Healthy Gulf, ManaSota-88, Our Santa Fe River, People for Protecting Peace River, RISE St. James, Sierra Club's Florida and Delta chapters, Suncoast Waterkeeper, Tampa Bay Waterkeeper, Waterkeeper Alliance, Waterkeepers Florida, which includes all 14 of Florida's waterkeeper groups, and WWALS Watershed Coalition seeking the promulgation of rules that: (1) reverse the Environmental Protection Agency's (EPA) 1991 Bevill regulatory determination excluding phosphogypsum and phosphoric acid production process wastewater ("process wastewater") from the Resource Conservation and Recovery Act (RCRA) Subtitle C hazardous waste regulations; (2) govern the safe treatment, storage and disposal of phosphogypsum and process wastewater as hazardous wastes under RCRA Subtitle C; (3) initiate the prioritization process for designating phosphogypsum and process wastewater as high priority substances for risk evaluation under the Toxic Substances Control Act (TSCA) §6(b)(1)(B)(i); (4) require manufacturers to conduct testing on phosphogypsum and process wastewater under TSCA §4(a)1(A)(ii); and (5) determine under TSCA §5(a) that the use of phosphogypsum in road construction is a significant new use.

In considering this petition, note that EPA has already acknowledged—and scientific research demonstrates—the current improper management of phosphogypsum and process water poses a substantial present hazard and an unreasonable risk of injury to human health and the environment.

Thank you for your consideration.

On behalf of Petitioners,

Rachael Curran, Esq.
People for Protecting Peace River
P.O. Box 3354
Arcadia, FL 34265
Phone: 727-537-0802
E-mail: rachael@curranlaw.org

Jaclyn Lopez, Esq.
Center for Biological Diversity
P.O. Box 2155
St. Petersburg, FL 33731
Phone: 727-490-9190
E-mail: jlopez@biologicaldiversity.org

cc:

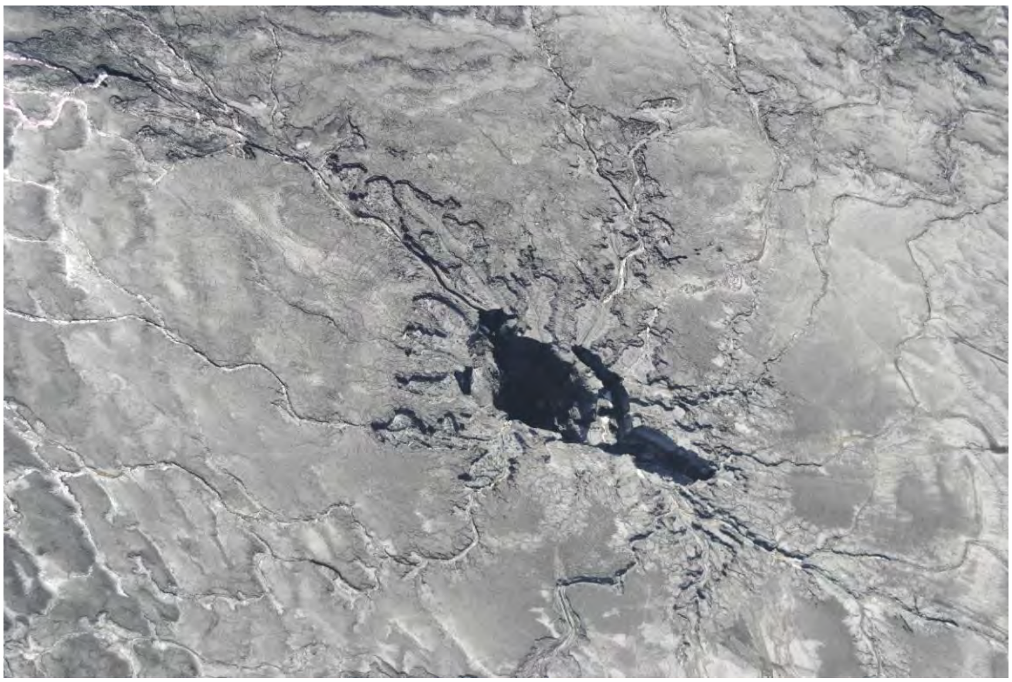
Office of Land and Emergency Management, Environmental Protection Agency, 1200 Pennsylvania Avenue, N.W., #5101T, Washington, DC 20460

Office of Chemical Safety and Pollution Prevention, Environmental Protection Agency, 1200 Pennsylvania Avenue, N.W., #7101M, Washington, DC 20460

Enclosures

BEFORE THE ADMINISTRATOR, ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF LAND AND EMERGENCY MANAGEMENT
and
OFFICE OF CHEMICAL SAFETY AND POLLUTION CONTROL

NOTICE OF PETITION FOR RULEMAKING PURSUANT TO SECTION 7004(A) OF THE RESOURCE CONSERVATION AND RECOVERY ACT, 42 U.S.C. § 6974(A); SECTION 21 OF THE TOXIC SUBSTANCES CONTROL ACT, 15 U.S.C. § 2620; AND SECTION 553(e) OF THE ADMINISTRATIVE PROCEDURE ACT, 5 U.S.C § 553(e), CONCERNING THE REGULATION OF PHOSPHOGYPSUM AND PROCESS WASTEWATER FROM PHOSPHORIC ACID PRODUCTION



A massive sinkhole in a phosphogypsum stack in Mulberry, Florida, which drained 215 million gallons of radioactive process wastewater and an undetermined amount of radioactive phosphogypsum into the Floridan aquifer, the primary drinking water source for 10 million people. Photo: Hannah Connor/Center for Biological Diversity, Sept. 20, 2016.

PEOPLE FOR PROTECTING PEACE RIVER, ATCHAFALAYA BASINKEEPER, BAYOU CITY WATERKEEPER, CALUSA WATERKEEPER, CENTER FOR BIOLOGICAL DIVERSITY, CHEROKEE CONCERNED CITIZENS, HEALTHY GULF, MANASOTA-88, OUR SANTA FE RIVER, RISE ST. JAMES, SIERRA CLUB DELTA CHAPTER, SIERRA CLUB FLORIDA CHAPTER, SUNCOAST WATERKEEPER, SUWANNEE RIVERKEEPER, TAMPA BAY WATERKEEPER, WATERKEEPER ALLIANCE, WATERKEEPERS FLORIDA, WWALS WATERSHED COALITION

PETITIONERS

FEBRUAY 8, 2021

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People for Protecting Peace River
P.O. Box 3354
Arcadia, FL 34265

People for Protecting Peace River (3PR) is a non-profit 501(c)(3) organization incorporated in the State of Florida and committed to educating the public on the extraordinary value of the natural and agricultural lands of the Peace and Myakka River watersheds. Two of 3PR's primary goals are to end the damage caused by phosphate strip mining and fertilizer processing, and to promote a superior quality of life in Florida's heartland near the Peace River. In furtherance of its mission, 3PR seeks to maintain the rural quality of life characteristic to the region; keep natural soils intact; be free of the danger of harmful pollutants left in the ground and aquifer after phosphate mining and fertilizer processing; and see the beauty of Florida's unique natural world left for future generations to experience and appreciate. Many of 3PR's members live within the rural areas of Central Florida's Bone Valley adjacent to or near proposed phosphate mines and expanding phosphogypsum stacks. Appreciation of rural Florida, including its natural peacefulness and unique biodiversity, is one of the main reasons many of 3PR's members live in the area.

Atchafalaya Basinkeeper
P.O. Box 410
Plaquemine, LA 70764

Atchafalaya Basinkeeper, a member organization of Waterkeeper Alliance, was founded by Dean Wilson in 2004 with a mission to protect and restore the swamps, lakes, rivers, streams and bayous of the Atchafalaya Basin for future generations. At the onset, Atchafalaya Basinkeeper set out to save Louisiana's coastal cypress forests from ongoing destruction by the cypress mulch industry. After working as a commercial fisherman for 16 years, Dean witnessed first-hand the systematic destruction of the Basin at the hands of regulators and private interests. Since its inception, Basinkeeper has worked to patrol and advocate for the Basin through education, monitoring and enforcement. Atchafalaya Basinkeeper works with diverse partner organizations, communities, agencies, regulated industry commercial and recreational users of the Basin, outdoor enthusiasts and concerned citizens in collective stewardship to preserve this ecological wonder.

Bayou City Waterkeeper
2010 N. Loop West, Ste 103
Houston, TX 77018

Bayou City Waterkeeper utilizes science, the law, and community empowerment to protect and restore our natural systems, achieve equitable policy solutions, and advance systematic change to benefit all who live within the Lower Galveston Bay watershed. Our activities include policy analyses and power mapping, targeted litigation against polluters and unscrupulous real estate developers, and the development of focused advocacy campaigns to drive change at the local, regional, and state level. At our core, our efforts center around ensuring

equal protection from environmental hazards, promoting nature-based solutions for climate adaptation, and providing opportunities for meaningful citizen involvement in decisions that affect environmental health. We aim to empower residents to address water-related issues in their own community, hold polluters and those in power accountable, and ensure our leaders have the tools to restore and conserve our natural systems

Calusa Waterkeeper
P.O. Box 1165
Fort Myers, FL 33902

Calusa Waterkeeper is a non-profit 501(c)(3) organization incorporated in the State of Florida dedicated to the protection of the Caloosahatchee River & Estuary, Lake Okeechobee, Nicodemus Slough, Charlotte Harbor, Estero Bay, the near-shore waters of Lee County, and their watersheds, through education and promotion of responsible use and enjoyment by all people. Calusa Waterkeeper, Inc. began in 1995 as Caloosahatchee River Citizens Association, Inc. (Riverwatch). We were admitted to Waterkeeper Alliance in 2015 as an Affiliate. In December 2016 we achieved full Member status in Waterkeeper Alliance, adopting the new name Calusa Waterkeeper, Inc.

Center for Biological Diversity
P.O. Box 2155
St. Petersburg, FL 33731

At the Center for Biological Diversity, we believe that the welfare of human beings is deeply linked to nature – to the existence in our world of a vast diversity of wild animals and plants. Because diversity has intrinsic value, and because its loss impoverishes society, we work to secure a future for all species, great and small, hovering on the brink of extinction. We do so through science, law and creative media, with a focus on protecting the lands, waters and climate that species need to survive.

Cherokee Concerned Citizens
1502 Cherokee St.
Pascagoula, MS 39581

The Cherokee Concerned Citizens is a fenceline community organized to protect the health and well-being of our families and neighbors from exposure to industrial pollution.

Healthy Gulf
PO Box 2245
New Orleans, LA 70176

Healthy Gulf's purpose is to collaborate with and serve communities who love the Gulf of Mexico by providing research, communications and coalition-building tools needed to reverse the long-pattern of over exploitation of the Gulf's natural resources.

ManaSota-88
P.O. Box 1728
Nokomis, Florida 34274

ManaSota-88 has spent over 50 years fighting to protect our environment. We are a 501.c3 non-profit organization, incorporated in the State of Florida. We are dedicated to protecting the public's health and preservation of the environment. Created in 1968, ManaSota-88 evolved from a major environmental health study sponsored by the U.S. Public Health Service, Florida State University, the University of Florida and the Sarasota and Manatee County Commissions. Our commitment to safeguard the air, land and water quality is aggressive and uncompromising. ManaSota-88 volunteers are unpaid. A steering committee provides overall leadership and direction. We operate entirely through volunteer support. We receive no contributions from the government or special interest groups. ManaSota-88 does not accept contributions from any polluting industries. Private citizens contribute 100% of our operating revenues.

Our Santa Fe River
2070 SW County Road 138
Fort White, FL 32038

Our Santa Fe River, Inc. is an all-volunteer 501(c)(3) organization formed in 2007 for the initial purpose of fighting off four companies seeking permits to bottle water from our iconic springs in north central Florida, and through a public appeal was successful in fending them off. Our completely volunteer citizen organization operates in the United States in the state of Florida and has evolved to endeavor to educate people to be good stewards of our waters and continue to advocate for the health and proliferation of our river, its springs and its underlying aquifer. More information is available at www.oursantferiver.org.

Rise St. James
P.O. Box 27
Vacherie, LA 70090

RISE St. James is a non-profit, grassroots, faith-based organization formed to advocate for racial and environmental justice in St. James Parish, Louisiana.

Sierra Club Delta Chapter
716 Adams Street
New Orleans, LA 70118

Sierra Club Florida Chapter
2127 S. Tamiami Trail
Osprey, FL 34229

The Sierra Club is America's largest and most influential grassroots environmental

organization, with more than 3.8 million members and supporters. In addition to protecting every person's right to get outdoors and access the healing power of nature, the Sierra Club works to promote clean energy, safeguard the health of our communities, protect wildlife, and preserve our remaining wild places through grassroots activism, public education, lobbying, and legal action. For more information, visit www.sierraclub/delta and www.sierraclub/florida.

Suncoast Waterkeeper
PO BOX 1028
Sarasota, FL 34230

Suncoast Waterkeeper (SCWK) is a Florida non-profit public benefit corporation with members throughout Southwest Florida, including Pinellas, Hillsborough, Sarasota, Manatee, and Charlotte Counties. SCWK is dedicated to protecting and restoring the Florida Suncoast's waterways on behalf of its members through enforcement, fieldwork, advocacy, and environmental education for the benefit of the communities and SCWK's members that rely upon these precious coastal resources. To further its mission, SCWK actively seeks federal and state implementation of environmental laws, and, where necessary, directly initiates enforcement actions on behalf of itself and its members. SCWK has been registered as a non- profit corporation in Florida since 2012 and is a licensed member of Waterkeeper Alliance, Inc., an international non-profit environmental organization, made up of over 300 separate Waterkeeper programs.

Tampa Bay Waterkeeper
260 1st Avenue South, Box 226
St. Petersburg, FL 33701

Tampa Bay Waterkeeper (TBWK) is a Florida non-profit public benefit corporation with members throughout the Tampa Bay watershed. TBWK is dedicated to protecting and improving the Tampa Bay watershed while ensuring swimmable, drinkable and fishable water for all. TBWK's approach combines sound science, policy advocacy, grassroots community engagement and education to stand up for clean water together as a community, ensuring a clean and vibrant future for the Tampa Bay watershed. To further its mission, TBWK actively seeks federal and state implementation of environmental laws and, where necessary, directly initiates enforcement actions on behalf of itself and its members. TBWK is a licensed member of Waterkeeper Alliance, Inc., an international non-profit environmental organization, made up of over 300 separate Waterkeeper programs.

WWALS Watershed Coalition (Suwannee Riverkeeper)
PO BOX 88
Hahira, GA 31632

WWALS Watershed Coalition (WWALS) advocates for conservation and stewardship of the Withlacoochee, Willacoochee, Alapaha, Little, Santa Fe, and Suwannee River watersheds in South Georgia and North Florida through education, awareness, environmental monitoring, and citizen activities. Suwannee Riverkeeper is a staff position and a project of WWALS as the member of Waterkeeper Alliance for the Suwannee River Basin. WWALS opposes expansion of

the decades-old moonscape of a phosphate mine in Hamilton County, Florida and another proposed in Union and Bradford Counties. We oppose such mines anywhere, which is why we drafted the Resolution Against Phosphate Mines in Florida that Waterkeepers Florida passed as one of its first acts.

Waterkeeper Alliance
180 Maiden Lane, Suite 603
New York, NY 10038

WATERKEEPER® ALLIANCE

Waterkeeper Alliance is a global movement uniting more than 350 Waterkeeper groups around the world, focusing citizen action on issues that affect our waterways, from pollution to climate change. The Waterkeeper movement patrols and protects over 2.75 million square miles of rivers, lakes, and coastlines in the Americas, Europe, Australia, Asia, and Africa. For more information please visit: www.waterkeeper.org.

Waterkeepers Florida
291 Cubbedge Road
St. Augustine, FL 32080

WATERKEEPERS® FLORIDA

Waterkeepers Florida is a regional entity composed of all 14 Waterkeeper organizations working throughout the State of Florida to protect and restore our water resources across over 45,000 square miles of watershed which is home to over 15 million Floridians. For more information, visit: www.WaterkeepersFlorida.org.

Petitioners meet the Administrative Procedure Act (APA), Resource Conservation and Recovery Act (RCRA), and Toxic Substances Control Act (TSCA) statutory meanings of "person" and have the right to petition the government for a redress of grievances.[1] The APA requires that each agency "shall give an interested person the right to petition for the issuance . . . of a rule."[2] RCRA authorizes "any person" to seek the repeal or promulgation of a rule, and indeed encourages public participation in the development of any regulation or program by stating that such participation shall be "provided for, encouraged, and assisted" by the EPA.[3] TSCA provides that "[a]ny person may petition [EPA] to initiate a proceeding for the issuance of a rule" under sections governing the testing, prioritization, risk evaluation, and regulation of chemical substances.[4]

[1] *See* U.S. Const. amend. I ("Congress shall make no law … abridging the right of people … to petition the Government for redress of grievances.").
[2] 5 U.S.C. § 553(e).
[3] 42 U.S.C. § 6974.
[4] 15 U.S.C. § 2620.

II. Action Requested

Pursuant to section 7004(a) of RCRA,[5] RCRA's implementing regulations,[6] section 21 of TSCA,[7] and section 553(e) of the APA,[8] Petitioners hereby petition the Administrator of the EPA to: (1) issue a rule reversing EPA's 1991 Bevill regulatory determination excluding phosphogypsum and process wastewater from phosphoric acid production ("process wastewater") from RCRA Subtitle C[9] hazardous waste regulation;[10] (2) promulgate regulations under RCRA Subtitle C governing the safe treatment, storage and disposal of phosphogypsum and process wastewater as hazardous wastes;[11] (3) initiate the prioritization process for designating phosphogypsum and process wastewater as high priority substances for risk evaluation under TSCA §6(b)(1)(B)(i);[12] (4) issue a testing rule under TSCA §4(a)1(A)(ii) requiring phosphogypsum and process wastewater manufacturers to develop information with respect to health and environmental effects relevant to a determination that the disposal of these chemical substances does or does not present an unreasonable risk of injury to health or the environment;[13] and (5) make a determination by rule under TSCA §5(a) that the use of phosphogypsum in road construction is a significant new use.

EPA must respond to this petition within certain statutory timeframes. RCRA requires EPA to "take action" within a "reasonable time" and to "publish notice of such action in the Federal Register, together with the reasons therefor."[14] TSCA requires EPA to either grant or deny this petition for rulemaking within 90 days and to "promptly commence an appropriate proceeding if such action is warranted."[15] Furthermore, should EPA decline to regulate phosphogypsum and process wastewater under TSCA, EPA must publish the reasons for its denial in the Federal Register.[16] The APA also requires that "[p]rompt notice shall be given of the denial in whole or in part of a written application, petition, or other request of an interested person made in connection with any agency proceeding."[17] Courts may compel agency action unlawfully withheld or unreasonably delayed pursuant to the APA.[18] RCRA further allows for

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[5] 42 U.S.C. § 6974(a).
[6] 40 C.F.R. § 260.20.
[7] 15 U.S.C. § 2620.
[8] 5 U.S.C. § 553(e).
[9] 42 U.S.C. §§ 6921—6939g.
[10] 40 C.F.R. § 261.4(b)(7). While the D.C. Circuit has distinguished between a determination and a regulation specifically in the context of RCRA Bevill regulatory determinations, the reversal sought by Petitioners constitutes an agency action subject to judicial review. See *Am. Portland Cement All. v. EPA*, 101 F.3d 772, 776 (D.C. Cir. 1996); *see also Brock v. Cathedral Bluffs Shale Oil Co*., 796 F.2d 533, 539 (D.C.Cir.1986).
[11] Adding specific standards for phosphogypsum and process wastewater to 40 C.F.R. Part 266.
[12] 15 U.S.C. § 2605(b)(1)(B)(i).
[13] 15 U.S.C. § 2603(a)(1)(A)(ii); "Manufacture," as defined by TSCA §3(9), means "to import . . .to produce, or manufacture." Phosphoric acid manufacturers also produce phosphogypsum and process wastewater. While chemical data reporting rules under TSCA §8 apply only to chemicals manufactured for distribution in commerce, of which phosphogypsum (with the exception of limited agricultural and road construction applications) and process wastewater are not, rules under §§4 and 6 are not subject to this limitation. 15 U.S.C §2602(9); 15 U.S.C. 2607(f).
[14] 42 U.S.C. § 6974(a).
[15] 15 U.S.C. § 2620(b)(3).
[16] *Id.*
[17] 5 U.S.C. § 555(e).
[18] 5 U.S.C. §706(1).

citizen suits against the EPA for failure to perform any nondiscretionary duty,[19] while TSCA provides for citizen suits against the EPA challenging a constructive denial whereby EPA fails to grant or deny a petition within the 90-day period.[20]

Petitioners may also challenge a denial of this petition under the APA,[21] RCRA and TSCA.[22]

III. Introduction

Over 70 mountainous piles of radioactive, toxic and hazardous waste scattered throughout the United States in Arkansas, Florida, Idaho, Illinois, Iowa, Louisiana, Mississippi, Missouri, North Carolina, Texas, Utah, and Wyoming,[23] concentrated among low-wealth communities. They pose a substantial present and future hazard and an unreasonable risk of injury to human health and the environment. EPA to date has abdicated its responsibility to evaluate and minimize the unreasonable risk or ensure protection of human health and the environment through adequate regulation.

Phosphogypsum is the radioactive, toxic waste created during wet-process phosphoric acid production, at a rate of approximately 5.2 tons for every ton of phosphoric produced.[24] Phosphoric acid is the intermediate feedstock of granular and liquid ammonium phosphate fertilizers.[25] In the United States, phosphoric acid is produced from phosphate rock mined from mineral deposits in Florida, North Carolina, Utah, and Idaho, with the largest deposit and the majority of the nation's phosphate mining occurring in Florida, where 27 strip mines span more than 450,000 acres.[26]

After strip mining and beneficiation to remove sand and clay from the phosphate matrix, calcium phosphate ore is transported to a fertilizer plant for processing by chemically digesting the phosphate ore in sulfuric acid.[27] This reaction results in a slurry of phosphoric acid and phosphogypsum (calcium sulfate dihydrate or calcium sulfate hemihydrate, depending on the type of wet process) as a suspended solid, at a rate of five tons of phosphogypsum waste for every one ton of phosphoric acid.[28] The phosphoric acid solution is filtered from the phosphogypsum and concentrated through evaporation to be sold as merchant-grade phosphoric acid, feed-grade phosphoric acid, and superphosphoric acid, or used as feedstock for finished

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[19] 42 U.S.C. § 6972(a)(2).
[20] 15 U.S.C. § 2620(b)(4).
[21] 5 U.S.C. §704.
[22] 42 U.S.C § 6976(a)(1); 15 U.S.C. § 2620(b)(4).
[23] EPA, *TENORM: Fertilizer and Fertilizer Production Wastes*, https://www.epa.gov/radiation/tenorm-fertilizer-and-fertilizer-production-wastes#tab-2 (last visited Feb 1, 2020).
[24] *Id.*
[25] United States Geological Survey, *Mineral Commodities 2020*, https://pubs.usgs.gov/periodicals/mcs2020/mcs2020.pdf.
[26] *Id.*; Florida Department of Environmental Protection, *Florida's Phosphate Mines*, https://floridadep.gov/water/miningmitigation/content/phosphate#:~:text=Today%20phosphate%20mining%20occurs%20primarily,North%20Florida%20(Hamilton%20County.
[27] EPA, *Report to Congress on Special Wastes from Mineral Processing* (1990) at 12-1.
[28] *Id.* at 12-2.

fertilizer products like diammonium phosphate (DAP) or monoammonium phosphate (MAP).[29] The phosphogypsum waste is then reslurried with recycled process wastewater and pumped via pipeline for disposal in a settling pond impoundment atop a waste pile known as a phosphogypsum stack,[30] where the phosphogypsum settles, thereby growing the stack.[31] The settled phosphogypsum is dredged to build up embankments at the sides of the impoundment containing the process wastewater.[32] Cooling ponds containing process wastewater are also situated at or below grade along the perimeter of the stack.[33] The process wastewater is meant to be primarily recycled in fertilizer plant operations, making uninterrupted plant operation critical to maintaining a negative process water balance.[34] Even still, during periods of unplanned precipitation, discharges to surface waters are often permitted by the state.[35]

While modern, active stacks and adjacent cooling ponds are lined with a single synthetic geomembrane liner, these liners have torn and are designed to leak (i.e., permeable), creating a "zone of discharge"[36] in the surficial aquifer that is explicitly allowed by permit in the state of Florida.[37] As a stack grows in height, the settling impoundment atop the stack decreases in size until the settling pond capacity becomes too small and the pumping height requires too much energy.[38] At this point the stack is either expanded horizontally, or it reaches the end of its useful life.[39]

Phosphogypsum contains calcium sulfate and several contaminants including radionuclides from uranium, thorium and radium which decay to harmful radon gas, toxic heavy metals; fluoride; ammonia; and residual phosphoric and sulfuric acids.[40] The process wastewater also contains these harmful toxic constituents, an is highly acidic and corrosive with pH measurements as low as 0.5.[41]

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[29] *Id.*
[30] Alternatively called "pond water" by industry and state regulating agencies. *See,* Typical Pond Water Analysis, http://www.fipr.state.fl.us/about-us/phosphate-primer/process-water/ (last visited July 17, 2020). "Process wastewater" also includes phosphogypsum stack runoff, wastewater generated from the uranium recovery step of phosphoric acid production, process wastewater from animal feed production, and process wastewater from superphosphate production. Mining Waste Exclusion, Final Rule, 55 Fed Reg. 2322, 2328 (Jan. 23, 1990) Uranium recovery from phosphate processing became uneconomic in the 1990s. Gerald Steiner et al. 2020. Making Uranium Recovery from Phosphates Great Again? 54 Environ. Sci. Technol. 1287, https://pubs.acs.org/doi/pdf/10.1021/acs.est.9b07859.
[31] Report to Congress, *supra* note 27 at 12-4.
[32] *Id.*
[33] *Id.*
[34] *Id.* at 12-2.
[35] *Id.*
[36] The horizontal extent of a permitted zone of discharge is typically the property boundary, but groundwater contamination exceeding drinking water standards often extends well beyond the zone. Report to Congress, *supra* note 27 at 12-13.
[37] Fla. Admin Code 62-673.320 (6).
[38] Carter, O.C. et. al. 1994. *Investigation of Metal and Non-Metal Ion Migration through an Active Phosphogypsum Stack*, INTERNATIONAL LAND RECLAMATION AND MINE DRAINAGE CONFERENCE AND THIRD INTERNATIONAL CONFERENCE ON THE ABATEMENT OF ACIDIC DRAINAGE at 199, https://www.asrs.us/Portals/0/Documents/Conference-Proceedings/1994-Volume-4/0199-Carter.pdf.
[39] *Id.*; *see also*, Ardaman & Associates, *Phase III Expansion Application*, Mosaic Fertilizer, LLC – New Wales Facility, Florida Department of Environmental Protection permit #MMR_FL0036421. (Oct. 25, 2019).
[40] Report to Congress, *supra* note 27 at 12-31.
[41] Report to Congress, *supra* note 27 at 12-4.

Phosphogypsum stack systems as currently managed are prone to extensive groundwater contamination, dike breaches, leakage, unexplained seepage, sinkholes, instability that threatens outright collapse, and excess process water balances in the event of a plant shutdown or abandonment necessitating intentional large-volume releases of process water to prevent further catastrophe.[42] Furthermore, this underregulated waste stream has been abused as a repository for illegal dumping for other already designated hazardous wastes.[43]

In 2019, the U.S. phosphate fertilizer industry was responsible for generating approximately 40 million tons of phosphogypsum.[44] While 50 percent of the phosphoric acid product was exported, 100 percent of the phosphogypsum waste remained in the United States, stored in ever-expanding phosphogypsum stacks near the fertilizer facilities that generated it.[45] Phosphogypsum stacks can be well over one square mile wide (800 acres)[46] and 500 feet tall[47] and collectively store over one billion tons of phosphogypsum and billions of gallons of process water in Florida alone.[48]

There are no imminent shortages of phosphate rock, and global consumption of phosphoric acid is expected to increase by 3 million tons in 2023.[49] In Florida, where the majority of the nation's phosphate mining occurs, the phosphate industry plans to strip mine an additional 90,905 acres for phosphate over the next 50 years, producing approximately another

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[42] Report to Congress, *supra* note 27 at 12-31.

[43] *See* Consent Decree, *United States of America and Louisiana Department of Environmental Quality v. Mosaic Fertilizer, LLC*, 15-cv-04889 (Sept. 30, 2015). https://www.epa.gov/sites/production/files/2015-10/documents/mosaiclouisiana-cd_0.pdf; Consent Decree, *United States of America and Florida Department of Environmental Protection v. Mosaic Fertilizer, LLC* (Sept. 30, 2015) https://www.epa.gov/sites/production/files/2016-03/documents/florida-cd.pdf; Consent Decree, *United States of America v. J.R. Simplot Company and Simplot Phosphates,* LLC, 20-CV-125-F (July 9, 2020), https://www.epa.gov/sites/production/files/2020-07/documents/jrsimplotcompany-cd.pdf.

[44] Based on 23 million metric tons of phosphate rock produced by US mines in 2019. United States Geological Survey, *Mineral Commodities 2020*, https://pubs.usgs.gov/periodicals/mcs2020/mcs2020.pdf. The wet process requires 3.3 metric tons of phosphate ore to produce 1 metric ton of phosphoric acid. ML2R Consultancy, *Raw Materials Requirements* http://ml2rconsultancy.com/raw-materials-requirements/. One metric ton equals 1.10231 tons. For every ton of phosphoric acid produced, 5.2 tons of radioactive phosphogypsum is generated.

[45] *Id.*

[46] EPA, *TENORM: Fertilizer and Fertilizer Production Wastes*, https://www.epa.gov/radiation/tenorm-fertilizer-and-fertilizer-production-wastes#tab-2.

[47] EPA, *Major Fertilizer Producer Mosaic Fertilizer, LLC to Ensure Proper Handling, Storage and Disposal of 60 Billion Pounds of Hazardous Waste / Manufacturer committing close to $2 billion in funding to address environmental impacts* (Oct. 1, 2015), https://www.epa.gov/enforcement/reference-news-release-major-fertilizer-producer-mosaic-fertilizer-llc-ensure-proper.

[48] *See*, Florida Department of Environmental Protection, *Geospatial Open Data, Mosaic Fertilizer, LLC New Wales South Stack*, https://geodata.dep.state.fl.us/datasets/6277c3b1eeae4a818f8683fc29e6b35b_0/data?geometry=-85.687%2C27.517%2C-78.364%2C29.209&page=2; Macías, Francisco et. al. 2017. *Environmental Assessment and Management of Phosphogypsum According to European and United States of America Regulations*, 17 PROCEDIA EARTH AND PLANETARY SCIENCE 666. One phosphogypsum stack system in Florida alone has a process wastewater inventory of 1.672 billion gallons as of May 12, 2020. JBM&R Engineering, Inc, *2020 Interim Stack System Management Plan*, Mosaic Fertilizer, LLC – New Wales Facility, Florida Department of Environmental Protection permit #MMR_FL0036421. (June 29, 2020).

[49] United States Geological Survey, *Mineral Commodities 2020*, https://pubs.usgs.gov/periodicals/mcs2020/mcs2020.pdf.

billion tons of phosphogypsum from processing Florida phosphate rock alone.[50] Thus, these mountains of radioactive waste that are already a part of several states' environmental legacies will only get exponentially larger and more dangerous with time if the EPA does not take immediate action.

IV. Statutory Background

A. The Resource Conservation and Recovery Act

Finding that land is "too valuable a national resource to be needlessly polluted by discarded materials,"[51] Congress passed RCRA in 1976 to address increasing problems associated with the growing volume of industrial and municipal waste. RCRA's goals include reducing the amount of solid waste generated, ensuring that these wastes are managed in an environmentally sound manner,[52] and protecting human health and the environment from the potential hazards of waste disposal. To achieve these goals, RCRA established two distinct programs: (1) the solid waste program, under RCRA Subtitle D, encourages states to develop comprehensive plans to manage nonhazardous industrial solid waste and municipal solid waste, sets criteria for municipal solid waste landfills and other solid waste disposal facilities, and prohibits the open dumping of solid waste; and (2) the hazardous waste program, under RCRA Subtitle C, establishes a "cradle to grave" system for controlling hazardous waste from the time it is generated until its final disposal.

Within the meaning of solid waste, RCRA further defines "hazardous waste" as any discarded material "which because of its quantity, concentration characteristics, or physical, chemical or infectious characteristics may—

> (A) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or
> (B) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed."[53]

In its proposed regulatory framework for implementing the RCRA Subtitle C hazardous waste program, EPA first introduced the concept of "special wastes," which include mining, beneficiation, and ore processing because of their typically high volumes and perceived low—

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[50] Based on a projected 734,170,244 tons of phosphate rock production in Central Florida over a 50-year period. *See* United States Army Corps of Engineers, Areawide Environmental Impact Statement for the Central Florida Phosphate District, Appendix H, Tables 3 and 5. Using the wet process, it takes 3.3 metric tons of phosphate rock to produce one metric ton of phosphoric acid (1 metric ton equals 1.10231 tons). Ml2R Consultancy, *Raw Materials Requirements*, http://ml2rconsultancy.com/raw-materials-requirements/ (last visited Feb 1, 2021).
[51] 42 U.S.C. § 6901(b).
[52] "'Solid waste' means any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities," subject to certain exclusions. 42 U.S.C. § 6903(27).
[53] 42 U.S.C. § 6903(5).

but at the time understudied—hazard to human health and the environment. While the EPA's "special wastes" concept did not make it into the final rules published in 1980, it formed the basis of the Bevill Amendment passed by Congress later that year.

1. The Bevill Amendment

The 1980 Bevill Amendment suspended EPA's authority to regulate "special wastes," including mining and mineral processing wastes, as hazardous under Subtitle C until six months after EPA's completion of a detailed study on the adverse human health and environmental effects and a published Bevill determination for each particular category of special waste. Study requirements for mineral processing wastes like phosphogypsum and process wastewater included analysis of the following:

> (1) the source and volumes generated per year;
> (2) present disposal and utilization practices;
> (3) potential danger, if any, to human health and the environment from disposal and reuse;
> (4) documented cases in which danger to human health or the environment has been proved;
> (5) alternatives to current disposal methods;
> (6) the costs of such alternatives;
> (7) the impact of those alternatives on the use of phosphate rock and uranium ore, and other natural resources; and
> (8) the current and potential utilization.[54]

The EPA took more than a decade to make a Bevill determination for mineral processing wastes, including phosphogypsum and process wastewater.[55]

2. The Simpson Amendment

The 1984 Simpson Amendment provided that EPA can modify some of the requirements of Subtitle C for special wastes that the agency determines are hazardous waste. The modifications can account for the unique characteristics of mining and processing wastes and the practical difficulties associated with implementation, but must "assure protection of human health and the environment."[56] The amendment specifically lists phosphate mining and processing wastes as wastes eligible for this Subtitle C regulatory flexibility.[57]

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[54] 42 U.S.C. § 6982(p).
[55] Special Wastes From Mineral Processing (Mining Waste Exclusion); Final Regulatory Determination and Final Rule, 56 Fed. Reg. 27300 (June 13, 1991).
[56] 42 U.S.C. § 6924.
[57] 42 U.S.C. § 6924(x).

B. The Toxic Substances Control Act as Amended by the Frank R. Lautenberg Chemical Safety Act of the 21st Century

The Toxic Substances Control Act of 1976 directs EPA to evaluate new and existing chemicals and their risks to human health and the environment, and to then implement regulations to manage unacceptable risks, therefore preventing or reducing pollution caused by these substances before they enter the environment. Under TSCA, EPA has the authority to impose record-keeping, reporting and testing requirements upon manufacturers, and to develop restrictions relating to chemical substances[58] and mixtures.[59] Once a substance is evaluated for risk, if EPA determines the risk of injury to human health and the environment is unreasonable, EPA must propose regulations under §6(a) to remove the unreasonable risk.

Faced with a significant backlog in EPA's evaluation and management of existing chemicals, the Frank R. Lautenberg Chemical Safety Act of 2016 mandated EPA evaluate existing chemicals for their risk of injury to human health and the environment, including a system of prioritization, with clear and enforceable deadlines. The amendment also directed EPA to conduct risk-based chemical evaluations without consideration of costs to the industry.

1. Prioritization under §6

A high-priority substance is a chemical substance EPA determines *may* present an unreasonable risk of injury to health or the environment because of a *potential* hazard and a *potential* route of exposure under the "conditions of use," which include disposal.[60] EPA must prioritize and make risk of injury determinations without consideration of costs, and include consideration of the risk to potentially exposed or susceptible subpopulations.[61]

EPA notes that through the prioritization process, EPA is ultimately making a judgment as to whether or not a particular chemical substance warrants further assessment and ultimately a §6(b) risk evaluation as a high priority substance.[62] It intends to select as high-priority chemicals those with the greatest hazard and exposure potential first.[63] Low priority substances are thus chemicals that EPA has determined, based on sufficient information to establish and without consideration of costs or other non-risk factors, that a §6(b) risk evaluation is not warranted at the time of priority designation.[64]

Once the prioritization process is initiated, EPA must publish a notice in the Federal Register, beginning a 90-day period during which interested persons may submit relevant

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[58] "Chemical substance" means any organic or inorganic substance of a particular molecular identity, including— (i) any combination of such substances occurring in whole or in part as a result of a chemical reaction or occurring in nature, and (ii) any element or uncombined radical. 15 U.S.C. § 2602(2).
[59] The term "mixture" means any combination of two or more chemical substances if the combination does not occur in nature and is not, in whole or in part, the result of a chemical reaction. 15 U.S.C. § 2602(10).
[60] 40 C.F.R. § 702.3
[61] *Id.*
[62] Procedures for Prioritization of Chemicals for Risk Evaluation under Toxic Substances Control Act; Final Rule, 82 Fed. Reg. 33753 (July 20, 2017); 40 C.F.R §702.
[63] 40 C.F.R. § 702.5(a).
[64] 40 C.F.R. § 702.3.

information,[65] including information relevant to the following screening factors EPA will use to decide whether to propose designation as a high-priority or low-priority substance:

(1) Hazard and exposure potential;
(2) Persistence and bioaccumulation;
(3) Potentially exposed or susceptible subpopulations;
(4) Storage near significant sources of drinking water;
(5) Conditions of use or significant changes in conditions of use, which include disposal;
(6) Production volume or significant changes in production volume; and
(7) Other risk-based criteria that EPA determines to be relevant to the designation of the chemical substance's priority.[66]

After conducting the screening review, EPA must then propose to list the chemical as either a high-priority or low-priority substance, and the proposed designation is subject to another 90-day public comment period.[67] A final high-priority designation is only appropriate after EPA initiates prioritization and the close of the second 90-day comment period. The entire prioritization process may take 9-12 months from the date of the first publication of the notice of initiation of prioritization.[68]

Once a substance is designated as a high priority substance, a risk evaluation is initiated and EPA has three years, subject to a possible one-time extension of six months, to complete the evaluation and make a final determination of risk.[69] For substances that EPA has determined pose an unreasonable risk, EPA has one year, extendable by up to two years, to propose a rule under §6(a) where the EPA takes action to manage or minimize the risk so that it is no longer unreasonable. Such action can include, among others, a ban, limitation on quantities produced, or regulation governing disposal.[70]

2. Testing Rules under §4

To facilitate the policy that "adequate information should be developed with respect to the effect of chemical substances and mixtures on health and the environment and that the development of such information should be the responsibility of those who manufacture and those who process such chemical substances and mixtures,"[71] TSCA requires EPA to direct testing on a chemical substance or mixture if it finds the following criteria are met:

(1) the "manufacture, distribution in commerce, processing, use, or disposal of a chemical substance or mixture, or that any combination of such activities, may present an unreasonable risk of injury to health or the environment,"

[65] 40 C.F.R. § 702.7(d).
[66] 40 C.F.R. § 702.9(a).
[67] 40 C.F.R. § 702.9.
[68] 40 C.F.R. § 702.1(d).
[69] 40 C.F.R. § 702.49.
[70] 15 U.S.C. § 2605(a).
[71] 15 U.S.C. § 2601(b)(1).

(2) "there is insufficient information and experience upon which the effects of such manufacture, distribution in commerce, processing, use, or disposal of such substance or mixture, or of any combination of such activities on health or the environment can reasonably be determined or predicted," and
(3) "testing . . . is necessary to develop such information."[72]

3. Significant New Use Rules under §5(a)

A Significant New Use Rule promulgated under TSCA §5(a) requires notice to EPA before a chemical substance or mixture is used in a new way that might create environmental or human health concerns.[73] Under TSCA §5(a)(2), EPA must make a determination by rule as to whether a new use of a chemical substance is a significant new use, after considering all relevant factors, including the following:

- Projected volume of manufacturing and processing of a chemical substance.
- Extent to which a use changes the type or form of exposure of humans or the environment to a chemical substance.
- Extent to which a use increases the magnitude and duration of exposure of humans or the environment to a chemical substance.
- Reasonably anticipated manner and methods of manufacturing, processing, distribution in commerce, and disposal of a chemical substance.[74]

Once EPA determines that a use of a chemical substance is a significant new use, TSCA § 5(a) requires manufacturers and processors to submit a Significant New Use Notice to EPA at least 90 days before they manufacture or process the chemical substance for that new use.[75] During this review period, EPA must assess risks that may be associated with the significant new use, including risks to potentially exposed or susceptible subpopulations identified as relevant by EPA under the conditions of use and then make another determination as to whether the significant new use presents an unreasonable risk of injury to health or the environment, without consideration of costs or other non-risk factors.[76] If EPA determines the significant new use does present an unreasonable risk, EPA must regulate the proposed activity either by order prohibiting or limiting the manufacture, processing, or distribution in commerce of the substance, or by proposed rule under §6(a), to the extent necessary to protect against the unreasonable risk.[77]

V. Regulatory History of Phosphogypsum Stacks

EPA has acknowledged the need for comprehensive federal phosphogypsum stack regulation since at least 1984, when it stated its reason for declining to propose radionuclide emission standards for phosphogypsum stacks under §112 of the Clean Air Act (CAA) at the time was that RCRA was the more appropriate statute for regulating phosphoric acid production

[72] 15 U.S.C. § 2603(a)(1)(A)(ii).
[73] 15 U.S.C. § 2604(a).
[74] 15 U.S.C. § 2604(a)(2).
[75] 15 U.S.C. § 2604(a).
[76] 15 U.S.C. § 2604(a)(3).
[77] 15 U.S.C. § 2604(f).

wastes.[78] While still not making its required Bevill regulatory determination for mineral processing special wastes or proposing tailored solid waste management guidelines under RCRA Subtitle D, EPA subsequently reevaluated the need for radionuclide emission standards under the CAA after preliminary risk assessments indicated individual lifetime risks of cancer from exposure to radon emissions from existing stacks were as high as eight in ten thousand and that population risks were on the order of one fatal cancer per year.[79]

Eventually in 1989, citing concern that radium-rich phosphogypsum would be incorporated into other products and diffused throughout the country such that EPA would be unable to ensure phosphogypsum radon emissions do not present an unacceptable risk to public health, EPA promulgated a National Emissions Standards for Hazardous Air Pollutants (NESHAP) rule in the form of a work practice standard that required all phosphogypsum be disposed into stacks or old phosphate mines.[80] The rule also limited radon emissions from stacks to a flux of 20 pCi/m^2-s, but EPA acknowledged both the stack requirement and the numerical radon flux emission standard imposed on the stacks were simply a maintenance of the status quo, as phosphogypsum stacks were already standard industry practice, and the NESHAP imposed no additional control technology since EPA believed all existing stacks already met the numerical radon flux standard.[81] In other words, EPA did nothing to manage or reduce the measured risk of fatal cancer from radon exposure that at the time applied to 95 million people living within 80 kilometers of a stack.[82] Testing to demonstrate compliance with the flux standard need only be measured one time once a stack becomes inactive. If the standard is met, it never needs to be tested again.[83]

Still, with industry unsatisfied with the total ban on off-site uses of phosphogypsum, EPA amended the NESHAP in 1992 to allow for agricultural use so long as the radium content in the phosphogypsum does not exceed 10 pCi/g,[84] and in 1994, increased the permitted distribution of phosphogypsum to up to 7,000 pounds at a time for research and development activities.[85]

After a series of lawsuits imposing a deadline and requiring EPA to narrow the scope of its Bevill Amendment interpretation, EPA completed its study of phosphogypsum under RCRA and submitted the required report to Congress for 20 mineral processing special wastes, including phosphogypsum and process wastewater, in 1990.[86] The study found widespread

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[78] Withdrawal of Proposed Standards, National Emission Standards for Hazardous Air Pollutants; Regulation of Radionuclides, 49 Fed. Reg. 43906, 43914 (Oct. 31, 1984).
[79] *Id.*
[80] An old phosphate mine receiving phosphogypsum waste would then also become a "phosphogypsum stack" for the purposes of the NESHAP. National Emission Standards for Hazardous Air Pollutants; National Emissions Standards for Radon Emissions from Phosphogypsum Stacks; Final Rule, 54 Fed. Reg. 51654, 51675 (Dec.19, 1989).
[81] *Id.*
[82] *Id.*
[83] *Id.*
[84] EPA amended the NESHAP upon petitions to reconsider from The Fertilizer Institute, Consolidated Minerals, Inc., and U.S. Gypsum Co. National Emission Standards for Hazardous Air Pollutants; National Emissions Standards for Radon Emissions from Phosphogypsum Stacks, Final Rule, 57 Fed. Reg. 23305 (June 3, 1992).
[85] 40 C.F.R. Subpart R.
[86] *Concerned Citizens of Adamstown v. EPA* imposed the deadline. No. 84-3041 (D.D.C. Aug. 21, 1985); *Environmental Defense Fund v. EPA*, (EDF II) held EPA can only apply the Bevill exclusion to wastes generated in

groundwater contamination at phosphogypsum stack sites including contaminated off-site wells, the potential for drinking water source exposures, several documented damage cases that impacted both ground and surface waters and threatened and harmed aquatic life, increased air pathway cancer risk for those living near stacks, and varied and inadequate state regulation.[87] Constituents of most concern that present a hazard to human health and included radionuclides, arsenic, chromium, selenium, cadmium, radium-226, lead, vanadium, copper, antimony, thallium, fluoride, and selenium.[88] The report also found an increased hazard and contaminate release potential should the industry expand in the absence of Subtitle C regulation.[89]

Nevertheless, due to costs to the industry in complying with a Subtitle C program, EPA's determination published the following year exempted phosphogypsum and process wastewater (as well as all other special wastes) from Subtitle C regulation.[90] The determination promised a Subtitle D solid waste program with tailored minimum federal guidelines[91] for 18 of the special wastes, and announced the development and future promulgation of a TSCA regulatory program for phosphogypsum and process wastewater. EPA further stated it planned to use existing authorities under either RCRA §7003 or the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) §106 to address site-specific phosphogypsum and process wastewater groundwater contamination problems that pose substantial and imminent endangerment to human health or the environment.[92]

As part of its development of a TSCA regulatory program, EPA chartered the Phosphoric Acid Waste Dialogue Committee under the Federal Advisory Committee Act in 1992 to determine if TSCA could effectively regulate phosphoric acid wastes.[93] According to a later EPA report as part of EPA's 1998 Phase IV Land Disposal Restriction rulemaking, the dialogue committee could not identify any feasible in-plant process changes that would significantly reduce the volume and/or toxicity of phosphogypsum or phosphoric acid process wastewater.[94] The exact nature of the dialogue committee's activities, including which process changes were considered and what criteria were used to determine feasibility remain unknown, as EPA has acknowledged that the dialogue committee's report is "missing" from its document collection,

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high volume with *low* toxicity, in accordance with EPA's original "special waste" concept, as opposed to all mineral processing wastes. 852 F.2d 1316 (D.C. Cir. 1988); Report to Congress, *supra* note 27; Special Wastes From Mineral Processing (Mining Waste Exclusion), Final Regulatory Determination and Final Rule, 56 Fed. Reg. 27300 (June 13, 1991).

[87] Report to Congress, *supra* note 27.

[88] *Id.*

[89] *Id.* Both the industry and the size of many stacks have indeed expanded since 1990.

[90] Special Wastes From Mineral Processing (Mining Waste Exclusion), Final Regulatory Determination and Final Rule, 56 Fed. Reg. 27300 (June 13, 1991).

[91] EPA has acknowledged Subtitle D does not contain effective enforcement and oversight tools that would be necessary to create such a program, but said it would work with Congress to obtain these authorities, and would rely on the existing regulatory efforts of states to the extent possible. Regulatory Determination for Wastes from the Extraction and Beneficiation of Ores and Minerals, 51 Fed. Reg. 24,496 (July 21, 1986). Just as it never created a phosphogypsum and process wastewater TSCA program, EPA never created the subtitle D program for the other 18 mining processing special wastes.

[92] Special Wastes From Mineral Processing (Mining Waste Exclusion), Final Regulatory Determination and Final Rule, 56 Fed. Reg. 27300 (June 13, 1991).

[93] EPA, *Risks Posed by Bevill Wastes* at 7 (1997).

[94] *Id.* at 7—8.

perhaps destroyed in a basement flood with no available duplicate copies.[95] Nevertheless, somehow finding that TSCA regulation would not be possible, the EPA decided it would revisit the 1991 Bevill regulatory determination and determine whether RCRA Subtitle C regulation of phosphoric acid special wastes remained inappropriate.[96]

Following the conclusion of the dialogue committee, EPA evaluated the environmental risks posed by phosphogypsum and process wastewater at 13 Florida sites by applying the RCRA National Corrective Action Prioritization System to each site.[97] The results showed that all 13 facilities evaluated had groundwater contamination and all 13 would qualify as "high priority."[98] Despite this, EPA to date has neither revisited its Bevill determination for phosphogypsum and process wastewater nor initiated any rulemakings under TSCA concerning phosphogypsum and process wastewater.

VI. EPA's 1991 Bevill determination is reversible.

While the Bevill Amendment only requires one study and report to Congress for each special waste,[99] nothing precludes EPA from conducting additional study or revisiting the initial determination at a later date when more information about the present and potential hazard becomes known. Indeed, EPA has repeatedly acknowledged its authority to reverse its Bevill determination, starting with the notice publishing the determination itself:

> If information obtained or findings developed . . . are such that RCRA could better handle this matter, the Agency *will revisit today's regulatory determination*, and determine whether subtitle C regulation of the phosphoric acid special wastes remains inappropriate.[100]

EPA next suggested it would revisit its Bevill regulatory determinations for certain "high-risk" mining wastes in a 1997 rulemaking on various mining waste issues. The EPA cited concern about "environmental and natural resource damages from acid mine drainage, the use of cyanide and other toxic chemicals, radioactivity, stability of tailings and waste rock piles, and in-situ mining methods."[101]

In 2010, after a breach in an impoundment pond at the Tennessee Valley Authority's (TVA) Kingston, TN, power plant released 1.1 billion gallons of coal ash slurry, EPA revisited its May 2000 Bevill determination excluding coal combustion residuals from Subtitle C requirements. EPA proposed a reversal of its Bevill determination and regulation under Subtitle

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[95] Personal correspondence with EPA Docket Center, Arctic Slope Mission Services (ASMS) – Contractor, e-mail: docket-customerservice@epa.gov (Sept. 16, 2020).
[96] EPA, *supra* note *93.*
[97] *Id.*.
[98] *Id.*.
[99] *See Solite Corp. v. EPA*, 952 F.2d 473 (D.C. Cir. 1991).
[100] Special Wastes From Mineral Processing (Mining Waste Exclusion); Final Regulatory Determination and Final Rule, 56 Fed. Reg. 27300, 27316 (June 13, 1991).
[101] Second Supplemental Proposal on Treatment Standards for Metal Wastes and Mineral Processing Wastes, Mineral Processing and Bevill Exclusion Issues, and the Use of Hazardous Waste as Fill; Proposed Rule, 62 Fed. Reg. 26041, 26054 (May 12, 1997) ("the Agency is therefore seeking comment on whether reexamination of some Bevill wastes is warranted.")

C, or in the alternative, minimum federal standards under Subtitle D.[102] Multiple, similar large-volume releases, as discussed below, have occurred in the phosphoric acid production waste context since EPA's 1991 Bevill regulatory determination.

Furthermore, EPA's stated plans in its Bevill determination to use RCRA and CERCLA enforcement authorities to manage the substantial present and future hazards posed by phosphogypsum and process wastewater in lieu of Subtitle C regulation is contrary to RCRA's statutory purpose. RCRA and its implementing regulations are designed to *prevent* harm caused by solid and hazardous wastes, and to adequately protect human health and the environment by ensuring these wastes are properly managed and disposed of in the first place. EPA cannot continue to ignore this mandate by pointing to authority—rarely exercised in the case of mineral processing industries anyway—to enforce corrective action clean-up or abatement orders after the harm has already occurred (i.e., remediation of site-specific groundwater contamination) under a higher imminent and substantial endangerment standard. EPA must ensure proper management and disposal of phosphogypsum and process wastewater under RCRA Subtitle C by reversing its Bevill determination and listing the wastes as hazardous before looking to future corrective actions, as said corrective actions would not be necessary if the waste were properly and safely managed.

VII. Phosphogypsum and process wastewater are hazardous wastes requiring RCRA Subtitle C regulation.

RCRA regulations provide that a solid waste not excluded from regulation as a hazardous waste may be designated as a listed "toxic waste" (hazardous waste with toxic constituent(s)) or a "characteristic hazardous waste."[103]

The solid waste may be listed as a toxic waste if 1) it contains a toxic constituent listed in Appendix VIII to 40 C.F.R. § 261 and 2) an analysis of 11 enumerated factors supports a conclusion that the waste is "capable of posing a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of, or otherwise managed."[104] A "characteristic hazardous waste" must exhibit one of the four following hazardous waste characteristics: ignitability, corrosivity (as determined by pH), reactivity, or toxicity (as determined by a leaching test).[105]

As described below, phosphogypsum contains toxic constituents, and analysis of the 11 factors shows the waste is capable of posing substantial hazards and must be listed as a toxic

[102] Hazardous and Solid Waste Management System; Identification and Listing of Special Wastes; Disposal of Coal Combustion Residuals From Electric Utilities, Proposed Rule, 75 Fed. Reg. 35127 (June 21, 2010). The final rule adopted the Subtitle D minimum standards option, deferring a final Bevill regulatory determination "until additional information…needed to quantify the risks of CCR disposal, …the potential impacts of recent Agency regulations on the chemical composition of CCR, [and] the adequacy of the state programs" is available. Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities, Final Rule, 80 Fed Reg 21302, 21309 (April 17, 2015).
[103] 40 C.F.R. § 261.
[104] 40 C.F.R. § 261.11.
[105] 40 C.F.R. §§ 261.20—261.24.

waste. Process wastewater exhibits the characteristics of corrosivity and toxicity, satisfying the criteria for designation as a characteristic hazardous waste.[106]

A. Phosphogypsum satisfies RCRA's criteria for listing as a Toxic Waste.

1. Phosphogypsum contains toxic constituents.

Phosphogypsum leachate contains the following toxic constituents listed in Appendix VIII to 40 C.F.R. § 261: arsenic, lead, nickel, cadmium, chromium, silver, antimony, copper, mercury, and thallium,[107] with concentrations of arsenic and chromium in phosphogypsum solids also exceeding EPA's health-based screening criteria in 1990.[108] The substantial hazard to human health and the environment presented by these constituents are discussed below.

2. Phosphogypsum poses substantial hazards to human health and the environment.

a. Nature of the Toxicity Presented by Phosphogypsum Constituents

Arsenic

Arsenic is a protoplastic poison causing malfunctioning of cell respiration, cell enzymes and mitosis.[109] Several studies have noted an association between chronic exposure to high levels of arsenic and lung cancer in occupationally exposed subpopulations.[110] Prolonged ingestion of water contaminated with arsenic may result in the manifestations of toxicity in practically all systems of the human body.[111] Chronic oral exposure to inorganic arsenic causes a pattern of skin changes associated with changes in the blood vessels of the skin, including patches of darkened skin and the appearance of small "corns" or "warts" on the palms, soles, and torso.[112] Ingesting arsenic has been reported to increase the risk of cancer in the skin, liver, bladder, and lungs, and the Department of Health and Human Services has determined that inorganic arsenic is known to be a human carcinogen.[113]

Lead

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[106]In addition to satisfying listing criteria for a Toxic Waste, some phosphogypsum samples from Rock Springs, Wyoming also exhibited the toxicity characteristic for chromium in 1990 using the extraction procedure (EP) leach test. Report to Congress, *supra* note 27 at 12-3—12-4. The EP has since been replaced by the Toxicity Characteristic Leaching Procedure (TCLP). 40 C.F.R. § 261.24(a).
[107] Report to Congress, *supra* note 27 at 12-8.
[108] Report to Congress, *supra* note 27 at 12-6.
[109] Monisha, Jaishankar et al. 2014. Toxicity, Mechanism and Health Effects of Some Heavy Metals, 7 INTERDISCIP TOXICOL 60, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4427717/.
[110] Hughes, James et. al. 1998. Evaluation and Synthesis of Health Effects Studies of Communities Surrounding Arsenic Producing Industries, 17 INT'L J. EPIDEMIOL. (2):407, https://pubmed.ncbi.nlm.nih.gov/3042651/.
[111] Raitnake, R. N. 2003. Acute and Chronic Arsenic Toxicity, POSTGRAD MED J., https://pmj.bmj.com/content/postgradmedj/79/933/391.full.pdf
[112] Agency for Toxic Substances and Disease Registry, *Toxicological Profile for Arsenic* (2007), https://www.atsdr.cdc.gov/toxprofiles/tp2.pdf.
[113] *Id.*

Toxic effects of chronic lead exposure have been observed in every human organ system that has been rigorously studied. This is not surprising because the mechanisms that induce toxicity are common to all cell types and because lead is widely distributed throughout the body.[114] Adverse neurological, renal, cardiovascular, hematological, immunological, reproductive, and developmental effects, especially in children, have been observed at low measured blood levels (PbB) of less than 5 μg/d.[115] The Centers for Disease Control states that "no safe blood lead level in children has been identified."[116] The Department of Health and Human Services classifies lead and lead compounds as reasonably anticipated to be human carcinogens.[117]

Nickel

In nickel-sensitized individuals representing approximately 10-20% of the general population, dermal contact with a small amount of nickel or oral exposure to fairly low doses of nickel can result in dermatitis.[118] Occupational exposure to airborne nickel has caused chronic bronchitis, reduced lung function, and cancer of the lung and nasal sinus.[119] The Department of Health and Human Services has determined that metallic nickel may reasonably be anticipated to be a human carcinogen.[120]

Cadmium

Long-term exposure to cadmium through air, water, soil, and food leads to cancer and organ system toxicity such as skeletal, urinary, reproductive, cardiovascular, central and peripheral nervous, and respiratory systems.[121] Breathing air with very high levels of cadmium can severely damage the lungs and may cause death.[122] Chronic exposure to low levels of cadmium in the air results in a build-up of cadmium in the kidney and may result in kidney disease.[123] Damage to the lungs and nasal cavity has been observed in animals exposed to cadmium in the air.[124] Lung cancer has been found in some studies of workers exposed to cadmium in the air and studies of rats that breathed in cadmium.[125] Eating food or drinking water with very high cadmium levels severely irritates the stomach, leading to vomiting and diarrhea, and sometimes death.[126] Chronic ingestion of cadmium can lead to a build-up of

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[114] Agency for Toxic Substances and Disease Registry, *Toxicological Profile for Lead* (2020) at 4, https://www.atsdr.cdc.gov/toxprofiles/tp13.pdf.
[115] *Id.* at 3.
[116] *Id.* at 3.
[117] *Id.* at 9.
[118] Agency for Toxic Substances and Disease Registry, *Toxicological Profile for Nickel* (2005) at 7, https://www.atsdr.cdc.gov/toxprofiles/tp15.pdf.
[119] *Id.*.
[120] *Id.* at 6.
[121] Rahimzadeh, Mehrdad. 2017. Cadmium Toxicity: An Update, Caspian J Intern Med. 8(3): 135–145. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5596182/#:~:text=Long%2Dterm%20exposure%20to%20cadmium,hair%2C%20nail%20and%20saliva%20samples.
[122] Agency for Toxic Substances and Disease Registry, *Toxicological Profile for Cadmium* (2012) at 4, https://www.atsdr.cdc.gov/toxprofiles/tp5.pdf.
[123] *Id.*
[124] *Id.*
[125] *Id.*. at 5
[126] *Id.* at 5

cadmium in the kidneys and kidney disease.[127] Chronic exposure to low levels of cadmium can also cause bones to become fragile and break easily.[128] Animal studies indicate that the young are more susceptible than adults to a loss of bone and decreased bone strength from exposure to cadmium.[129] Kidney and bone effects have also been observed in laboratory animals ingesting cadmium, as well as anemia, liver disease, and nerve or brain damage.[130] The U.S. Department of Health and Human Services has determined that cadmium and cadmium compounds are known human carcinogens.[131]

Chromium

The primary effects associated with exposure to chromium(VI) compounds are respiratory, gastrointestinal, immunological, hematological, reproductive, and developmental, while the primary effects associated with exposure to chromium(III) compounds are on the respiratory and immunological systems.[132] Numerous epidemiological studies recognizing the association between chromium inhalation and lung cancer have been published since the 1940s.[133] The International Agency for Research on Cancer (IARC) has determined that chromium(VI) compounds are carcinogenic to humans.[134]

Silver

Silver compounds can cause some areas of the skin and other body tissues to turn gray or blue-gray, a permanent condition known as "argyria."[135] Argyria occurs in people who eat or breathe in silver compounds over a long period of several months to years.[136] Exposure to dust containing relatively high levels of silver compounds may cause breathing problems, lung and throat irritation and stomach pain.[137]

Antimony

EKG alterations were found in about 50% of the workers exposed to antimony compounds.[138] Other health effects that have been observed in animals orally exposed to higher doses of antimony include hepatocellular vacuolization, hematological alterations including

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[127] *Id.*. at 5
[128] *Id.*. at 5
[129] *Id.* at 6.
[130] *Id.* at 5
[131] *Id.*. at 5
[132] Agency for Toxic Substances and Disease Registry, *Toxicological Profile for Chromium* (2012), https://www.atsdr.cdc.gov/toxprofiles/tp7.pdf.
[133] Dayan, A.D. et. al. 2001. Mechanisms of Chromium Toxicity, Carcinogenicity and Allergenicity: Review of the Literature from 1985 to 2000, 20 HUMAN AND EXPERIMENTAL TOXICOLOY 439, https://journals.sagepub.com/doi/pdf/10.1191/096032701682693062.
[134] Agency for Toxic Substances and Disease Registry, *supra* note 132 at 4.
[135] Agency for Toxic Substances and Disease Registry, *Toxicological Profile for Silver* (1990), https://www.atsdr.cdc.gov/toxprofiles/tp146.pdf.
[136] *Id.*
[137] *Id.*
[138] Agency for Toxic Substances and Disease Registry, *Toxicological Profile for Antimony and Compounds* (2019), https://www.atsdr.cdc.gov/toxprofiles/tp23.pdf.

decreases in red blood cell counts and hemoglobin levels, and histological alterations in the thyroid.[139]

Copper

Long-term exposure to copper dust can irritate the nose, mouth, and eyes, and cause headaches, dizziness, nausea, and diarrhea.[140] Water that contains higher than normal levels of copper may cause vomiting, stomach cramps, or diarrhea.[141] Intentionally high intakes of copper can cause liver and kidney damage and even death. [142]

Mercury

The nervous system is highly sensitive to mercury.[143] Some people who ate fish contaminated with large amounts of methylmercury or seed grains treated with methylmercury or other organic mercury compounds developed permanent damage to the brain and kidneys.[144] Permanent damage to the brain has also been shown to occur from exposure to sufficiently high levels of metallic mercury.[145] The kidneys are also sensitive to the effects of mercury, because mercury accumulates in the kidneys and causes higher exposures to these tissues, and thus more damage.[146] All forms of mercury can cause kidney damage if large enough amounts enter the body.[147]

Thallium

Thallium can affect the human nervous system, lung, heart, liver, and kidney if large amounts are eaten or drunk for short periods of time.[148] Temporary hair loss, vomiting, and diarrhea can also occur and death may result after exposure to large amounts of thallium for short periods. Thallium can be fatal from a dose as low as 1 gram.[149] The Agency for Toxic Substances Disease registry reports no information was found on health effects in humans after exposure to smaller amounts of thallium for longer periods.[150] As in humans, animal studies indicate that exposure to large amounts of thallium for brief periods of time can damage the

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139 *Id.*
140 Agency for Toxic Substances and Disease Registry, *Toxicological Profile for Copper* at 6 (2004), https://www.atsdr.cdc.gov/ToxProfiles/tp132.pdf
141 *Id.*.
142 *Id.*. at 7
143 Agency for Toxic Substances and Disease Registry, *Toxicological Profile for Mercury* (1999), https://www.atsdr.cdc.gov/toxprofiles/tp46.pdf.
144 *Id.*.
145 *Id.*
146 *Id.*
147 *Id.*
148 Agency for Toxic Substances and Disease Registry, *Toxicological Profile for Thallium* (1992), https://www.atsdr.cdc.gov/toxprofiles/tp54.pdf.
149 *Id.*
150 *Id.*

nervous system and heart and can cause death. [151]Animal reproductive organs, especially the testes, are damaged after drinking small amounts of thallium contaminated water for 2 months.[152]

b. Concentration of Toxic Constituents in Phosphogypsum

Concentrations of toxic constituents vary from stack to stack according to the source phosphate ore processed. Concentrations of chromium and arsenic exceeded EPA's health-based risk screening criteria for inhalation in the 1990 study, meaning these constituents could pose a significant (i.e., greater than $1x10^{-5}$) risk if phosphogypsum were released to the ambient air as particles.[153] Concentrations of arsenic also exceeded EPA's health-based risk screening criteria for ingestion.[154]

c. Migration Potential

Metal and nonmetal ions in phosphogypsum are highly mobile when leached due the acidity of process water, indicating a strong potential for groundwater contamination.[155] Once groundwaters in karst geological terrains like those in Florida are contaminated with toxic phosphogypsum constituents by large-scale pollution events like sinkholes forming within a phosphogypsum stack, they are difficult if not impossible to remediate due to uncertainty in the fate and transport of contaminants after sinkhole collapse[156] and a need for a better understanding of karst processes and characterization of fast-moving conduit flow patterns.[157]

d. Persistence

Heavy metals are persistent in the environment.[158]

e. Degradation Potential and Rate of Degradation

All of the toxic constituents in phosphogypsum are metals or other inorganics that do not degrade.[159]

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[151] *Id.*
[152] *Id.*
[153] Report to Congress, *supra* note 27 at 12-7.
[154] *Id.*
[155] Carter, O.C. et al., *supra* note 38.
[156] Sandu, Daljit et. al. 2018. Fate and Transport of Radioactive Gypsum Stack Water Entering the Floridan Aquifer due to a Sinkhole Collapse, SCIENTIFIC REPORTS 8: 11439, https://www.nature.com/articles/s41598-018-29541.
[157] Sandu, Daljit. 2019. Implications of Groundwater Plume Transport and Analysis of Karst Aquifer Characteristics in Central Florida, UNIVERSITY OF CENTRAL FLORIDA, http://purl.fcla.edu/fcla/etd/CFE0007723.
[158] Ali, Hazrat et al. 2019. *Environmental Chemistry and Ecotoxicology of Hazardous Heavy Metals: Environmental Persistence, Toxicity, and Bioaccumulation,* J. CHEMISTRY, 2019: 6730305, https://www.hindawi.com/journals/jchem/2019/6730305/.
[159] EPA, *supra* note 27 at 12-1.

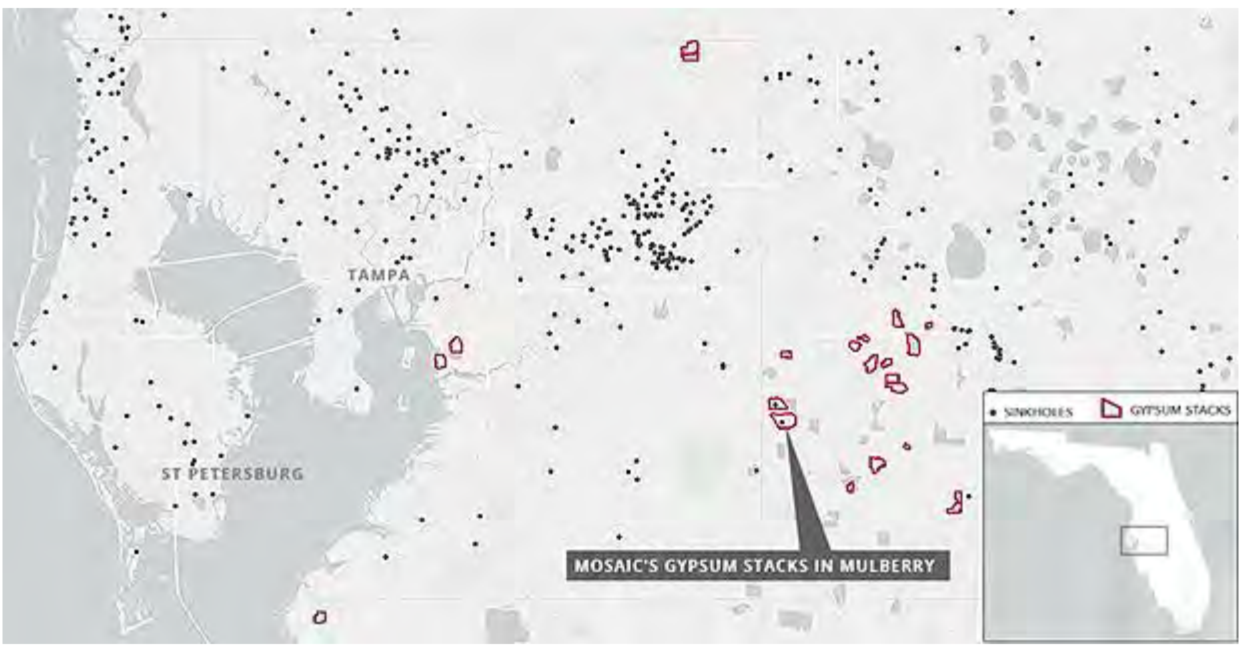
f. Bioaccumulation

Both chromium and arsenic, which exceeded EPA's health-based screening criteria for phosphogypsum solids in 1990, bioaccumulate in aquatic species.[160]

g. Plausible Improper Management

Phosphogypsum stack mismanagement is not only plausible, but numerous documented damage cases have already occurred. The following is a brief description of what can and has gone wrong as a result of inadequate federal regulation.

1. Phosphogypsum stacks and stack expansions are built in sinkhole-prone areas atop drinking water sources.



Location of phosphogypsum stacks in West-Central Florida among reported sinkholes from the Florida Geological Survey's subsidence incident reports database. The area is known as "Sinkhole Alley." Graphic: Claudine Hellmuth/E&E News (2020).

Since EPA's Bevill determination, there have been three reported major sinkholes, underneath phosphogypsum stacks, releasing millions of gallons of untreated process wastewater and an undetermined amount of phosphogypsum into the Floridan aquifer: the 1994 sinkhole beneath a stack at the New Wales facility in Mulberry, FL releasing 80 million gallons of process wastewater;[161] the 2009 sinkhole beneath a phosphogypsum stack at the PCS facility in White

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[160] Canivet, V. et. al., 2001. Toxicity and Bioaccumulation of Arsenic and Chromium in Epigean and Hypogean Freshwater Macroinvertebrates, 40 ENVT'L CONTAMINATION AND TOXICOL. 345, https://link.springer.com/article/10.1007/s002440010182.

[161] Marshall, James, *Mountains of Waste Menace Florida's 'Swiss Cheese' Aquifers,* E&E NEWS (Apr. 9, 2020), https://www.eenews.net/stories/1062576963.

Springs, Florida releasing 84 million gallons of process wastewater;[162] and most recently, the 2016 sinkhole beneath a phosphogypsum stack just 1.25 miles away from the 1994 original sinkhole at the New Wales facility in Mulberry, FL, releasing 215 million gallons of process wastewater.[163]

While still attempting to remediate the contamination caused by the 2016 sinkhole, Mosaic Fertilizer has applied for a 231-acre expansion of the same phosphogypsum stack.[164] And remediation of contamination in the Floridan aquifer is likely not even possible, as one study found "there is uncertainty in the fate of the contaminant waste after the sinkhole collapse"[165] and another study called for an improved understanding of karst processes and characterization of fast-moving conduit flow patterns.[166]

In addition to these reported sinkholes, at least two unreported sinkhole-like "anomalies" occurred in 2004 and 2013 at the same New Wales facility, releasing undetermined amounts of phosphogypsum and process wastewater to the aquifer below.[167]

2. Phosphogypsum stacks are single-lined at best.

All states containing phosphogypsum stacks have adopted the federal exclusion from hazardous waste regulations, and therefore do not require double liners with double leachate detection and collection systems above and between the liners.[168] While Florida's Phosphogypsum Management Rule now requires stacks to be lined with a single composite liner, the state of Florida allowed phosphate to be deposited in unlined stacks until March 25, 2001.[169] Louisiana considers phosphogypsum stacks to be solid waste landfills and has no regulations specific to phosphogypsum stacks, except that the regulatory authority may give "special consideration" to phosphogypsum stacks and waive or modify requirements, including the operation of liners and leachate collection and removal systems applicable to any other solid waste landfill.[170] These single liners are designed to leak and discharge water to underlying groundwater, creating a permitted "zone of discharge" in Florida.[171] Idaho does not currently apply any solid waste requirements to phosphogypsum stacks, but Idaho's Department of Environmental Quality is undergoing rulemaking for the design, construction, and management of phosphogypsum stacks and lateral expansions.[172] Mississippi, North Carolina, Texas, and Wyoming have no solid waste regulations specific to phosphogypsum stacks.[173]

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[162] *Id.*
[163] *Id.*
[164] Ardaman & Associates, Inc., Mosaic Fertilizer New Wales Phase III Expansion Application, FDEP Permit # MMR_FL0036421 Oct. 25, 2019).
[165] Sandu et. al., *supra* note 156.
[166] Sandu, *supra* note 157.
[167] Fuleihan, N.F. 2013. Investigation of 2013 Anomaly New Wales Plan Closed North Gypstack.
[168] Report to Congress, supra note 27 at 12-34—12-35.
[169] Fla. Admin. Code 62-673.440.
[170] La. Admin. Code 33 Part VII § N.1.
[171] EPA, *Risks Posed by Bevill Wastes* (1997) at 15.
[172] Idaho Department of Environmental Quality, Design and Construction of Phosphogypsum Stacks: Docket No. 58-0119-2001, https://www.deq.idaho.gov/public-information/laws-guidance-and-orders/rulemaking/design-and-construction-of-phosphogypsum-stacks-docket-no-58-0119-2001/.
[173] Report to Congress, supra note 27 at 12-34—12-35.

3. Phosphogypsum and process wastewater are not treated.

Despite high migration potential of contaminants within phosphogypsum and process water, neither is treated to remove impurities like radionuclides or heavy metals either while active or at time of closure. Process water is only treated by double-liming,[174] or in some cases reverse osmosis, when release is necessary to maintain surge capacity or to prevent an uncontrolled release.[175]

4. Phosphogypsum stacks are uncovered, open-air dumps.

Active phosphogypsum stacks as currently managed are entirely uncovered, open-air dumps. Even inactive portions of active stacks can remain uncovered until stack closure, when a vegetated cover is finally installed.[176] Phosphogypsum stacks with a soil cover of just 0.5 meters of dirt would emit less radon (6 pCi/m^2-s) than the current management practice of no soil cover (up to 20 pCi/m^2-s).[177] EPA has already concluded that phosphogypsum stacks pose a considerable air pathway cancer risk as a result of radon emissions.[178] In addition, disturbed phosphogypsum (e.g., construction vehicles driving over the stacks and removing the crust) and wind erosion cause fugitive dust emissions.[179] These dust emissions provide an inhalation pathway for toxic constituents within phosphogypsum particles, including arsenic, chromium, and radionuclides.[180] Combining the risk from radon inhalation from the stacks themselves with the risks of radionuclide, arsenic and chromium-containing particle inhalation, EPA estimated a total air pathway lifetime maximally exposed individual cancer risk of approximately $9x10^{-5}$.[181]

Long-term exposure to fine particulate matter also adversely affects the respiratory and cardiovascular systems and otherwise increases mortality risk.[182] For instance, particulate matter

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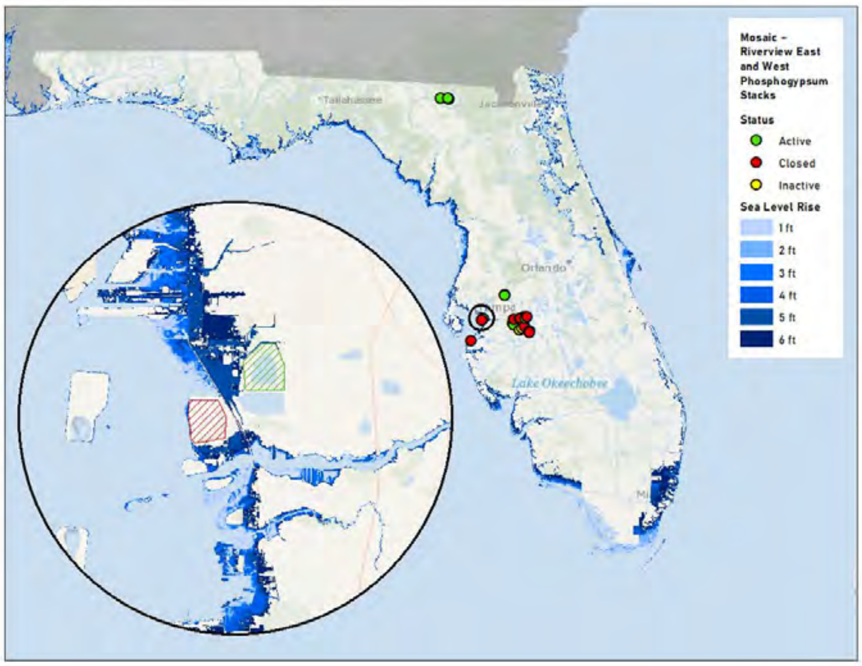
[174] Report to Congress, *supra* note 27 at 12-24.
[175] Peprich, Bill et. al. 2005. Mobile Wastewater Treatment Helps Remediate Concentrated Acidic Process Water at Fertilizer Plant*,* FLORIDA WATER RESOURCES JOURNAL*,* https://www.fwrj.com/TechArticle05/0705%20FWRJ_tech%201.pdf.
[176] Fla. Admin. Code 62-673.610.
[177] National Emission Standards for Hazardous Air Pollutants; National Emissions Standards for Radon Emissions from Phosphogypsum Stacks; Final Rule. 54 Fed. Reg. 51654, 51676 (Dec.19, 1989).
[178] Report to Congress, *supra* note 27 at 12-17.
[179] *Id.* In some parts of the country, fugitive dust emissions from wind erosion occur even without phosphogypsum disturbance. For example, in Idaho, phosphogypsum stacks have a sandy consistency that do not crust over due to the type of phosphate ore and beneficiation process used prior to phosphoric acid production. Idaho stacks also do no not receive the same level of dust suppression influenced by rainfall as stacks in the subtropical Southeast. Horton, Thomas (EPA). *A Preliminary Radiological Assessment of Radon Exhalation from Phosphate Gypsum Piles and Inactive Uranium Mill Tailings Piles* at 2 (1979).
[180] *Id.*
[181] *Id.*
[182] Wu, Xiao et al. 2020 (preprinted). Exposure to Air Pollution and COVID-19 Mortality in the United States: A Nationwide Cross-Sectional Study, Harvard Chan School of Public Health, https://www.medrxiv.org/content/medrxiv/early/2020/04/27/2020.04.05.20054502.full.pdf.

exposure is associated with an increased risk of COVID-19 death in the United States, with an increase of only 1 $\mu g/m^3$ associated with an 8% increase in the COVID-19 death rate.[183]

5. Phosphogypsum stacks and stack expansions are prone to dam breaches and are built in coastal areas vulnerable to sea level rise and hurricanes.

To effectuate the transport of phosphate rock and phosphoric acid to and from fertilizer facilities, associated nearby phosphogypsum stack systems are often located in coastal areas of the Gulf. The Gulf region is particularly vulnerable to sea level rise, with the highest rates of sea level rise in the nation occurring from the mouth of the Mississippi River westward,[184] where several stacks are located. As seas continue to rise in the coming decades, many of the Gulf coast stacks are likely to be catastrophically inundated, as illustrated below.



Graphic: Kara Clauser/Center for Biological Diversity

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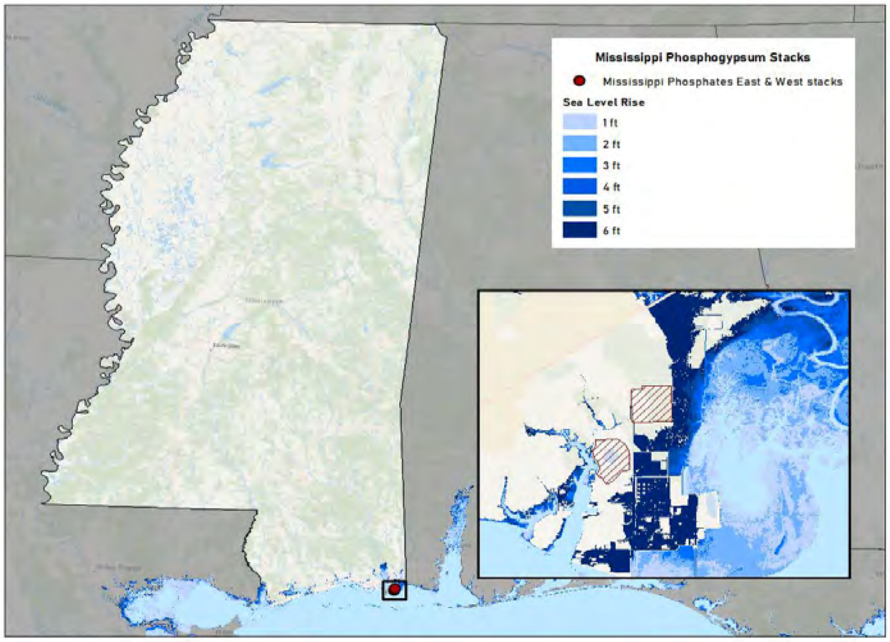
183 *Id.*

184 Lindsey, Rebecca (National Oceanic and Atmospheric Administration). 2012. *Climate Change: Global Sea Level,* https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level.



Graphic: Kara Clauser/Center for Biological Diversity

On this backdrop of rising sea levels, coastal regions are threatened by increased flooding and intensifying storm surge, which in combination further threaten the integrity of coastal phosphogypsum stacks and future stack expansions.[185] Coastal flooding is becoming more damaging as hurricane-generated storm surges grow more severe due to climate change.[186] Projections anticipate an increase in the acceleration of sea level rise in Florida,[187] which when combined with intensifying hurricanes and storm surge, is greatly increasing the flooding risk.[188] Under a lower emissions RCP 4.5 scenario, storm surge is projected to increase by 25 to 47 percent along the U.S. Gulf and Florida coasts due to the combined effects of sea level rise and growing hurricane intensity.[189] The increasing frequency of extreme precipitation events is also compounding coastal flooding risk when storm surge and heavy rainfall occur together.[190]

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[185] Climate Central, *Surging Seas Risk Zone Map*, http://sealevel.climatecentral.org/maps. (last visited Feb. 1, 2021).
[186] Hayhoe, Katherine et al. 2018. Our Changing Climate. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 72–144, https://nca2018.globalchange.gov/downloads/NCA4_Ch02_Changing-Climate_Full.pdf
[187] Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group. 2019. Unified Sea Level Rise Projection. A document prepared for the Southeast Florida Regional Climate Change Compact Climate Leadership Committee, https://southeastfloridaclimatecompact.org/wp-content/uploads/2020/04/Sea-Level-Rise-Projection-Guidance-Report_FINAL_02212020.pdf.
[188] Little, C. M. et al. 2015. Joint projections of US East Coast sea level and storm surge. Nature Climate Change 5:1114-1121, https://scholarship.libraries.rutgers.edu/discovery/delivery?vid=01RUT_INST:ResearchRepository&repId=12643403030004646#13643523080004646.
[189] Balaguru, K. et al. 2016. Future hurricane storm surge risk for the U.S. gulf and Florida coasts based on projections of thermodynamic potential intensity. Climatic Change 138:99-110.
[190] Wahl, T., S. Jain, J. Bender, S. D. Meyers, and M. E. Luther. 2015. Increasing risk of compound flooding from storm surge and rainfall for major US cities. Nature Climate Change 5:1093-1098, https://www.nature.com/articles/nclimate2736.epdf?no_publisher_access=1&r3_referer=nature

Flooding concerns extend to those associated with high tide. Since the 1960s, sea level rise has increased the frequency of high tide flooding by a factor of 5 to 10 for several U.S. coastal communities, and flooding rates are accelerating in many Atlantic and Gulf Coast cities.[191] A local sea level rise of 1.0 to 2.3 feet would be sufficient to turn nuisance high tide events into major destructive floods.[192] In Florida specifically, which could have over six feet of sea level rise by the end of the century, nuisance flooding due to sea level rise has already resulted in severe property damage and social disruption.[193] The frequency, depth, and extent of tidal flooding are expected to continue to increase in the future.[194] As the sea level rises, storm surge and tidal flooding will occur on an increasingly higher sea surface which will push water further inland and create more flooding.[195] With water pushed further inland, not just during storm surge events but also due to a general state of elevated sea level, areas once deemed suitable for phosphogypsum stack construction will no longer be so.

Climate change-driven and increasingly frequent, intense, and precipitous storms and hurricanes have already created major problems for phosphogypsum stack management, where maintaining design freeboard and surge capacity in process wastewater impoundments is critical to dam integrity and preventing large-volume releases to the environment. See section (i) below for a summary of major releases of untreated process wastewater to surface waters occurring since EPA last comprehensively reviewed phosphogypsum stack damage cases in 1990.

6. Phosphogypsum stacks are too large and appear to be built upon weak soils, and are thus subject to instability.

The north slope of Mosaic Fertilizer's No. 4 stack at the Uncle Sam facility in Convent, Louisiana has been subject to lateral movement since January 2019, putting surrounding communities and farms at risk of outright collapse and ecological disaster. The state's review of the root cause determined that a 5 to 10-foot zone of under-consolidated, interbedded weak organic and marine clay, ignored at the time of stack design, is at fault.[196] In 1990, EPA considered Louisiana phosphogypsum stacks higher than 12 meters (40 feet) to be unstable due to the weak nature of Louisiana soils.[197] Yet, because of inadequate federal oversight, the Uncle Sam stack is now nearing 60 meters (200 feet),[198] and is predictably unstable.

7. Phosphogypsum stack systems have been used to dump other listed hazardous wastes.

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[191] Hayhoe et al., *supra* note 186.
[192] *Id*.
[193] Wdowinski, S. et al. 2016. Increasing flood hazard in coastal communities due to rising sea level: Case study of Miami Beach, Florida. Ocean & Coastal Management 126:1-8.
[194] Hayhoe et al., *supra* note 186.
[195] Tebaldi, C. et al. 2012. Modelling sea level rise impacts on storm surges along US coasts. Environmental Research Letters 7:014032, https://iopscience.iop.org/article/10.1088/1748-9326/7/1/014032/pdf.
[196] Louisiana DEQ, Uncle Sam Facility, Government Review of Root Cause Analysis (March 2, 2020).
[197] Report to Congress, *supra* note 127 at 12-19.
[198] Wright, Tom. *Mosaic says it can keep wastewater on site in case of breach,* The Lens (Feb.19, 2019), https://thelensnola.org/2019/02/13/mosaic-says-it-can-keep-wastewater-on-site-in-case-of-breach/.

In 2015, EPA announced a record $2 billion RCRA settlement with Mosaic Fertilizer, LLC for illegally commingling 60 billion pounds of hazardous waste with Bevill-exempt waste at several facilities in Florida and Louisiana. More recently, EPA settled with J.R. Simplot Company in July 2020, where the company agreed to pay a civil penalty of $775,000, also for placing hazardous wastes in a Bevill-exempt phosphogypsum stack system.[199]

8. Phosphogypsum stacks use mechanical evaporators to spray hazardous process wastewater into the ambient air.

Mosaic Fertilizer installed four mechanical evaporators in 2019 at its New Wales facility in order to increase process wastewater evaporation and help maintain a negative process wastewater balance.[200] However, Mosaic has been unable to determine the amount of process wastewater evaporated in this way due to "numerous operational and climatic inputs and outputs."[201] Florida's Department of Environmental Protection (FDEP) authorized the use of these evaporators through NPDES and Title V air permit modifications without reviewing any industrial health testing conducted by the applicant[202], while Louisiana's Department of Environmental Quality (LDEQ) rejected a similar proposal at the Uncle Sam facility due to health and safety concerns.[203]

9. Phosphogypsum stack owners have gone bankrupt and abandoned their facilities, leaving emergency operations to state and federal environmental agencies.

Mulberry Phosphates at Piney Point, Palmetto Florida

Mulberry Phosphates declared bankruptcy in February 2001, giving the FDEP approximately 48 hours-notice that it would abandon its Piney Point facility and that the phosphogypsum stack there was in need of continuous maintenance for which the corporation would be unable to provide any of funding.[204] The total process water and pore volume the time was 1.2 billion gallons when Mulberry Phosphate Inc. declared bankruptcy.[205] Since each inch of rain that falls on the facility has been calculated to add approximately 12.5 million gallons of water to the process wastewater volume, a series of reasonably strong rain events adding 12 to 15 inches, or a 50 or 100- year storm, could overflow part of the berm and collapse the entire

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[199] Complaint, *United States of America v. J.R. Simplot Company and Simplot Phosphates, LLC*, 20-CV-125-F (July 9, 2020), https://www.justice.gov/enrd/consent-decree/file/1293116/download.
[200] Notification of Completion of Construction – Spray Evaporator System, Mosaic Fertilizer, LLC – New Wales Facility, Florida Department of Environmental Protection permit #MMR_FL0036421 (Nov 18, 2019).
[201] Mosaic Fertilizer, LLC , Quarter 1 Spray Evaporation Report– New Wales Facility, Florida Department of Environmental Protection permit #MMR_FL0036421 (April 28, 2020).
[202] Personal correspondence, Vishwas Sathe, FDEP Phosphogypsum Management Program (August 14, 2020).
[203] Louisiana DEQ, Letter for Water Management Options at the Mosaic Fertilizer, LLC - Uncle Sam Facility (July 30, 2019).
[204] Henderson, Carl. 2004. Piney Point Phosphate Plant: An Environmental Analysis at 40, UNIVERSITY OF SOUTH FLORIDA ST. PETERSBURG, https://digital.stpetersburg.usf.edu/cgi/viewcontent.cgi?article=1062&context=honorstheses.
[205] Similar to process water in chemical composition, pore water is not ponded, but rather interspersed throughout the stack. *Id*. at 41.

structure, releasing several million gallons of process water and some portion of the pore waters as a slurry and putting over 60 homeowners in the immediate area in imminent danger of a spill.[206]

The state moved to assume receivership in bankruptcy proceedings and was then forced to immediately discharge 50 million gallons of process wastewater after only single lime treatment into adjacent Bishop's Harbor.[207] Single lime treatment raises the process wastewater pH to 4.5 standard units and removes most of the metal constituents, but does not remove enough phosphorus or nitrogen to meet state or federal water quality standards or to be discharged on even a limited basis to surface waters such as the poorly flushed Bishop's Harbor.[208]

While the state managed the site, it intentionally released 248 million gallons of partially treated process wastewater into the Gulf of Mexico via 35 barge trips from July 20 to November 30, 2003.[209]

Between 2005 and 2009, FDEP drained and lined the ponds a top the stack as part of a project to "reclaim" the stack for beneficial reuse. Today the stack is managed by HRK Holdings, Inc. and is used for deposition of dredge material from the adjacent Port Manatee expansion activities. This attempted beneficial reuse of a phosphogypsum stack has been an utter failure, resulting in multiple liner tears and releases into Bishop Harbor, with a 2011 leak sending 170 million gallons in Bishop's Harbor.[210] HRK Holdings has informed local officials that the ponds are again nearing capacity, able to store only an additional 60 million gallons of water, or 19 inches of rainfall.[211]

Mississippi Phosphates in Pascagoula, Mississippi

Mississippi Phosphates Corporation filed for Chapter 11 bankruptcy in December of 2014, ceasing plant operations at the time and leaving more than 700 million gallons of In December of 2014, Mississippi Phosphates declared Chapter 11 bankruptcy, leaving more than 700 million gallons of process wastewater stored at the facility, with an additional nine million gallons generated for every one inch of rainfall.[212] The bankruptcy settlement established a trust which was used to pay for process wastewater treatment overseen by the state, but the funds were depleted on February10, 2017. The EPA's Superfund Removal Program took control of the facility on February 11 2017, and wastewater treatment is occurring at a rate of approximately 2,000,000 gallons per day at a cost to taxpayers of approximately $1,000,000 per month.[213]

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[206] *Id.*. at 40.
[207] *Id.* at 41.
[208] *Id.*.
[209] Hu, Chuanmin et al. 2003. Satellite monitoring of the FDEP Gulf dispersal of the Piney Point treated wastewater. University of South Florida at 2.
[210] Salman, John. *HRK knew of tearing problems before Piney Point spill*, THE BRADENTON HERALD (July 6, 2012), https://www.bradenton.com/news/business/article34551327.html.
[211] Pittman, Craig. *Phosphate waste threatens bay again, so what if we bottled it?* FLORIDA PHOENIX (Oct. 1, 2020), https://www.floridaphoenix.com/2020/10/01/phosphate-waste-threatens-bay-again-so-what-if-we-bottled-it/.
[212] EPA, Mississippi Phosphates Corporation Site Pascagoula, Mississippi Factsheet (March 2017), https://www.epa.gov/sites/production/files/2017-03/documents/mpc_fact_sheet_1_finalv2.pdf.
[213] *Id.*

Ground water beneath the plant is contaminated with arsenic, cadmium, lead, selenium and thallium at levels above EPA's Safe Drinking Water Act Maximum Contaminant Levels, and multiple city-owned groundwater wells are located within 4 miles of the site.[214] Surface soil contains arsenic above screening values for site workers and elevated levels of cadmium, chromium, lead, nickel, vanadium, radium-226, radium-228 and associated decay products. Bayou Cossette sediment is contaminated with arsenic, chromium and lead above screening values for the saltwater environment.[215]

h. Quantities of Waste Generated

As described above, phosphogypsum is produced at a rate of 5.2 tons of waste for one ton of phosphoric acid. Approximately 46 million tons of phosphogypsum are created in the U.S. annually.[216] A phosphogypsum stack can be over one square mile wide[217] and 500 feet tall,[218] and contain a process water inventory of over a billion gallons.[219] Over 30 million tons per year are produced in Florida alone,[220] and an estimated one billion tons are already stacked there.[221]

i. Nature and Severity of the Human Health and Environmental Damage that Has Occurred

Human Health Damage

A study examining mortality over decades in a cohort of Florida phosphate fertilizer plant workers found significant elevated mortality due to all causes, all cancers, lung cancer, and leukemia as compared to the overall U.S. population and the population of Florida, as well as increased incidence of mental disorders and chronic obstructive pulmonary disease (COPD).[222] Although an exposure-response relation could not be established due to limitations of the study, the authors noted that phosphate processing results in exposures to aerosolized radiation, acid vapors, and other airborne toxins.[223] Radiation exposure routes to fertilizer plant workers and local residents near fertilizer plants include external radiation, inhalation and ingestion of radionuclide-containing dust, and inhalation of radon and radon daughters.[224]

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[214] EPA, Mississippi Phosphates NPL Site Narrative (Jan. 2018), https://semspub.epa.gov/work/HQ/197100.pdf.
[215] *Id.*
[216] The Fertilizer Institute. Apr. 2020. *Revised Request for Approval of Additional Uses of Phosphogypsum Pursuant to 40 C.F.R. 61.206* at 6, https://www.epa.gov/sites/production/files/2020-10/documents/4-7-2020_pg_petition.pdf.
[217] EPA, *supra* note 46.
[218] EPA, *supra* note 47.
[219] JBM&R Engineering, Inc, *2020 Interim Stack System Management Plan*, Mosaic Fertilizer, LLC – New Wales Facility, Florida Department of Environmental Protection permit #MMR_FL0036421.
[220] Burnett, William C. et al.. 1996. Radionuclide Flow During the Conversion of Phosphogypsum to Ammonium Aulfate, 32 J. Envt'l Radioactivity. 33, https://doi.org/10.1016/0265-931X(95)00078-O.
[221] Macías, Francisco et al. 2017. Environmental Assessment and Management of Phosphogypsum According to European and United States of America Regulations, 17 PROCEDIA EARTH AND PLANETARY SCIENCE 666, 667, https://doi.org/10.1016/j.proeps.2016.12.178.
[222] Yiin, James et al. 2016. A Study Update of Mortality in Workers at a Phosphate Fertilizer Production Facility, 59 AM J IND MED. 12, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4913354/.
[223] *Id.*
[224] Kim, Kwang Po et al. 2006. Characterization of Radioactive Aerosols in Florida Phosphate Processing Facilities, 40 AEROSOL SCIENCE AND TECHNOLOGY 410, https://doi.org/10.1080/02786820600643313.

Petitioners are not aware of any phosphogypsum epidemiological studies evaluating residential (nonoccupational) exposure data and long-term health outcomes, a gap in science that EPA must rectify (see section XII).

Environmental Damage

The following is a summary of major releases to surface and groundwaters occurring since EPA last comprehensively reviewed phosphogypsum and process wastewater environmental damage cases in 1990.

Mobil Mining and Minerals in Pasadena, Texas: Cotton Patch Bayou Spill

On April 6, 1992, the southern retaining wall of Mobil Mining and Mineral's No. 3 phosphogypsum stack experienced structural failure, releasing 45 million gallons of phosphogypsum and process water with a pH of less than two standard units.[225] The release flowed into Cotton Patch Bayou and eventually the Houston Ship Channel through a barge basin, covering large areas of terrestrial and aquatic habitat and adversely affecting surface water quality within approximately seven miles of the Houston Ship Channel for at least a week, and a fish and macro-crustacean kill was observed.[226] Freshwater, marine, and estuarine wildlife, fish, invertebrates, plants, and sediments all sustained injuries, as well as terrestrial wildlife, plants, and soils.[227] Cotton Patch Bayou was severely impacted, and prior to the release the bayou provided habitat for species of songbirds and wading birds, terrestrial reptiles, amphibians, mammals, crayfish and numerous other invertebrates.[228]

Mulberry Phosphates in Mulberry, Florida: Alafia River Spill

During a rainstorm on December 7, 1997, the crest of the south wall containing a settlement pond atop the Mulberry Facility's south stack washed out, causing approximately 54 million gallons of process wastewater and an undetermined amount of phosphogypsum slurry to spill into Skin Sampling Creek and the North Prong of the Alafia River,[229] eventually traversing 35 miles of the Alafia River before reaching Hillsborough and Tampa Bays.[230] With a pH of 2, the process wastewater discharge drastically altered pH throughout the length of the Alafia River, with post-spill pH measurements ranging from 2.8 standard units in the upper, freshwater portion of the river to 4 standard units in the lower, estuarine portion for several days.[231]

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[225] Consent Decree for Natural Resource Damages, *United States of America v. Mobil Mining and Minerals Co.*, United States District Court for the Southern District of Texas, Case No.: H96-0695 (1996).
[226] *Id.*
[227] *Id.*
[228] *Id.*
[229] Amundsen & Moore, Summary Report of Determination of Cause of Process Water Discharge From South Gypsum Stack Expansion Area, Mulberry Phosphates, Inc., Mulberry, Polk County, Florida at 1, FDEP Permit # MMR_FL0334944 (Jan 20, 1998).
[230] National Oceanic and Atmospheric Administration, *Final Damage Assessment and Restoration Plan for December 7, 1997 Alafia River Spill* at 6 (July 21, 2000), http://www.atlassettlements.com/wp-content/uploads/Atlas_Settlements_Mulberry_Case_Study.pdf.
[231] *Id.*

Reported as the "worst environmental disaster in the Alafia River's history," the spill caused a significant fish kill reported throughout the length of the river from Mulberry to Hillsborough Bay, including an estimated 1.3 billion baitfish and shellfish and 72,900 gamefish.[232] The spill also caused injuries to freshwater benthic communities, oysters, and mussels.[233] Through the loss of habitat and prey, the spill may also have indirectly injured birds that utilize the Alafia River and surrounding wetlands, including for breeding.[234] Approximately 377 acres of freshwater vegetation were injured or lost to the spill, including the die-off of freshwater wetland vegetation and 8 acres of mature hardwoods.[235] And due to the 350 tons of nitrogen ultimately sent to Tampa Bay,[236] the spill caused imbalances in aquatic fauna, algae blooms, and increased chlorophyll *a* concentrations in both the river and bay through May of the following year.[237]

A consultant-led investigation determined that the dike breach formed as a result of the routine removal of a decant pipe and subsequent backfilling of the pipe trench with phosphogypsum, a process "similar to that used by many gypsum stack operators worldwide."[238]

Cargill Fertilizer in Riverview, Florida: South Archie Creek/ Hillsborough Bay Spill

During Hurricane Frances on September 5, 2004, high winds and rain eroded a berm atop a phosphogypsum stack at Cargill Fertilizer's Riverview Facility,[239] causing 65 million gallons of process wastewater to discharge into South Archie Creek and eventually Hillsborough Bay.[240] The spill caused documented death and injury to many estuarine dependent species, including tidal marsh, red, black, and white mangrove forests, salt grass, blue crab, fiddler crab, various shrimp species, water column organisms, sea grasses, sand seatrout, striped mullet, spadefish, stingray, croaker, menhaden, sea robin, hog choaker, white grunt, scaled sardine, mojarra, spotted seatrout, red drum, and common snook.[241] In addition, the open waters of Hillsborough Bay provide important habitat for seabirds, marine fish species, and marine mammals like the bottlenose dolphin and West Indian Manatee, although no direct injuries of these species were observed.[242] Approximately 78.4 acres of mangroves and 57.3 acres of tidal marsh experienced die-off, while 21.57 of 24.44 acres of seagrass along the shoreline of Hillsborough Bay showed signs of stress after contact with the process wastewater, with the remaining 2.87 acres of sea grass no longer visible after the discharge.[243]

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[232] Palmer, Tom. *Alafia River Appears to Have Healed After Acid Spill,* THE LEDGER (Dec. 9, 2007), https://www.theledger.com/article/LK/20071209/News/608133314/LL.
[233] National Oceanic and Atmospheric Administration, *supra* note 230 at 10.
[234] *Id*. at 11.
[235] *Id*. at 15.
[236] Palmer, Tom, *supra* note 232.
[237] National Oceanic and Atmospheric Administration, *supra* note 230 at 22.
[238] Amundsen & Moore, supra note 229 at 4—5.
[239] Now owned by Mosaic Fertilizer, LLC.
[240] Complaint for Natural Resource Damages, *United States of America et al. v. Mosaic Fertilizer, LLC*, Case No: 13-cv-00386-RAL-TGW (2013).
[241] Consent Decree, *United States of America et al. v. Mosaic Fertilizer, LLC*, Case No: 13-cv-00386-RAL-TGW, Appendix A at 9 (2013).
[242] *Id.* at 10.
[243] *Id.* at 11.

Mississippi Phosphates in Pascagoula, Mississippi: Bangs Lake and Bayou Cosette Spills

On April 14, 2005, a rainfall of 26 cm in less than 24 hours caused a stack breach at the Mississippi Phosphates facility, releasing over 17 million gallons of process wastewater and damaging marsh vegetation, fish, and oysters at the Bangs Lake station of the Grand Bay National Estuarine Research Reserve.[244] Seven years later, after 76 cm of rain fell from August 28-30 due to Hurricane Isaac, the facility released another 90 million gallons of process wastewater over the course of 3 days into Bayou Cosette, where a fish kill was observed.[245]

Prior to filing for bankruptcy, Mississippi Phosphates had been cited for hundreds of violations of its Clean Water Act permit for discharging wastewater that exceeded limits for ammonia, phosphorous, total suspended solids, fluoride, temperature, and pH.[246] In 2015, the company plead guilty to discharging over 38 million gallons of acidic process wastewater in August of 2013, failing to treat the water with caustics to mitigate its toxicity to marine life as required by its permit.[247] The illegal discharge resulted in the death of over 47,000 fish and the closing of Bayou Cosette, one of the most productive nurseries for aquatic species on the Gulf Coast.[248]

Releases to Groundwater

As detailed in section j.5 above, since the 1990 Report to Congress there have been three reported sinkholes in Florida releasing large volumes of phosphogypsum and process wastewater into the aquifer below. The contamination plume from the most recent of these, the 2016 Mosaic Fertilizer New Wales sinkhole in Mulberry, Florida, remains to this day as Mosaic continuously pumps over 4,000 gallons per minute from its recovery wells in an attempt to recover contaminated groundwater from the Floridan aquifer, a primary source of drinking water for the state. Approximately 215 million gallons of process wastewater and an undetermined amount of phosphogypsum entered the Floridan aquifer as a result of the sinkhole.

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[244] Beck, Marcus et al. 2018. Water Quality Trends Following Anomalous Phosphorus Inputs to Grand Bay, Mississippi, USA. Gulf and Caribbean Research, 29:1. http://ftp.sccwrp.org/pub/download/DOCUMENTS/WorkPlan/RestrictedJournalArticles/1018_GrandBayPhosphorousInputs.pdf.
[245] *Id.*
[246] Felony Information, *United States of America v. Mississippi Phosphates Corporation*, Case No.: 1:15-cr-00058-LG-RHW (2015).
[247] *Id.*
[248] *Id.*

j. Action Taken by Other Governmental Agencies or Regulatory Programs Based on the Health or Environmental Hazard Posed by Phosphogypsum Stacks

Florida adopted its Phosphogypsum Management Rule in 1993, which established a performance standard based on the permitted zone of discharge.[249] Stacks are required to be designed, operated, and maintained such that groundwater and surface water quality standards are not violated beyond the zone.[250] The state has entered into numerous consent orders and corrective action plans for permit violations. For instance, after the 2016 New Wales sinkhole, where Mosaic Fertilizer, LLC violated its permit's vertical zone of discharge by discharging into the Floridan aquifer, the FDEP and Mosaic entered into a consent order directing the company to study methods and technologies to locate "zones of weakness, solution cavities, erosion features or other subsurface anomalies" that may cause sinkholes.[251]

k. Other Appropriate Factors

1. Phosphogypsum stacks are disproportionately located in communities of color and low-wealth.

The proximity of massive volumes of phosphogypsum and process wastewater to vulnerable communities represents an environmental injustice. African-Americans are 75 percent more likely than other Americans to live in "fence-line" communities near industrial facilities, including those that produce hazardous waste, and are directly affected by the facilities' operation.[252] The injustice presented by phosphogypsum and process wastewater is made all the worse by the fact that the hazardous wastes stored near these communities are not currently managed in RCRA-permitted hazardous waste treatment, storage, and disposal facilities with strict manifest and land disposal requirements, but rather in underregulated open air stacks that emit radon and are prone to large-volume releases. The following are two examples of fence-line communities subject to the threat of nearby phosphogypsum stacks.

Riverview/Old Progress Village in Florida

The active phosphogypsum stack at Mosaic's Riverview facility south of Tampa currently sits adjacent to the historically Black community of Old Progress Village ("Progress Village"). Progress Village was designed in the 1950s as a means to provide home ownership to Tampa's segregated Black residents, who lived primarily in housing projects and were purposefully displaced by construction of an interstate.[253] The community learned in 1982 of then-owner Gardiner's plans to build a second phosphogypsum stack, this time across the street

[249] Fla. Admin. Code 62-673.340.
[250] *Id.*
[251] Consent Order, *State of Florida Department of Environmental Protection v. Mosaic Fertilizer, LLC*, OGC No. 16-1356 (Oct. 24, 2016).
[252] NAACP and Clean Air Task Force. 2017. Fumes Across the Fence Line: The Health Impacts of Air Pollution from Oil & Gas Facilities on African American Communities, https://www.naacp.org/climate-justice-resources/fumes-across-fence-line/.
[253] Baum, Laura E. 2016. Neighborhood Perceptions of Proximal Industries in Progress Village, FL, UNIVERSITY OF SOUTH FLORIDA SCHOLAR COMMONS (2016) at 7-8.

from Progress Village and near a school, and fought hard to stop the company from obtaining its necessary local permit. Community members organized petitions and protests and showed up in large numbers to several county commission meetings over the course of the next two years.[254] At one meeting, a resident voiced:

> What do you tell people 15 or 20 years from now when someone wants to know who let a company put two mountains of waste within the city limits of Tampa? How do you tell the next generation that we have messed up again? What do I tell my grandkids? Will their mother and father let them visit me? What do I do when I retire? I won't have the funds to move to the mountains or some resort area or take extended vacations in Europe. No, Mr. and Mrs. Commissioners. I'll be stuck with that gypsum pile the rest of my life. So, I appeal to you as God-fearing and law-abiding citizens. Please for one time give us a break. Let the little people win one. We already have an ammonia pipeline[255] running through Progress Village that could burst anytime. We don't need to be subjugated to another hazard. Vote no against the gypsum pile proposal.[256]

The little people did not win, and Hillsborough County commissioners approved the proposal in 1984.[257] Gardiner entered into an agreement with Progress Village leaders that year providing mostly short-term beautification benefits and a scholarship program.[258] There is some dispute if the agreement was necessary to gain county approval for stack construction or if it was merely a side deal aimed at bettering community relations.[259] Little remains of the benefits promised, but the growing radioactive, hazardous mountain will remain forever.[260]

Convent, St. James Parrish in Cancer Alley, Louisiana

Mosaic Fertilizer's Uncle Sam facility is located in an infamous 85-mile stretch of industrial area in southern Louisiana containing 150 facilities, known as Cancer Alley due to its increased cancer rates when compared to the rest of the nation.[261] The population of Convent, where the stack is located, is 62.20% Black, with average annual earnings of $35,667.[262] This community is now facing the consequences of an inadequately regulated stack system that has been permitted to grow too large and unstable given the weak nature of Louisiana soils noted by EPA three decades ago; the north slope of the facility's No. 4 phosphogypsum stack has been

[254] *Id*. at 71
[255] The ammonia pipeline through Old Progress Village was constructed in the 1970s to transport ammonia from the Port of Tampa to another fertilizer facility in Bartow, FL. *Id*. at 65.
[256] *Id.*. at 72-73.
[257] *Id*. at 74.
[258] *Id. at* 75.
[259] *Id*. at 73-74.
[260] *Id*. at 97.
[261] Pasley, James. *Inside Louisiana's Horrifying 'Cancer Alley,' an 85-mile Stretch of Pollution and Environmental Racism That's Now Dealing With Some of the Highest Coronavirus Death Rates in the Country*, BUSINESS INSIDER (April 9, 2020), https://www.businessinsider.com/louisiana-cancer-alley-photos-oil-refineries-chemicals-pollution-2019-11#in-total-about-150-facilities-line-the-alley-its-the-second-biggest-producer-of-petrochemicals-in-the-country-after-texas-but-the-key-difference-is-that-texas-industry-is-spread-out-over-hundreds-of-miles-5.
[262] Convent, Louisiana, *World Population Review*, https://worldpopulationreview.com/us-cities/convent-la-population (Source: US Census Bureau 2018 American Community Survey).

moving laterally since at least January 9, 2019.[263] In response, Mosaic has been shifting its process wastewater inventory from the pond atop the stack to other nearby ponds in an attempt to both relieve pressure caused by the weight of the process wastewater on the northern slope and to mitigate the damage caused in the plausible event of a collapse and resulting release of process wastewater from the pond onto adjacent agricultural fields and the surrounding community.[264] To date, however, the stack slope containing millions of gallons of process wastewater is still moving and threatening collapse.

2. Phosphogypsum is radioactive.

Phosphogypsum has very high levels of gross alpha and beta radiation (10 to 100 pCi/g) relative to levels in typical soils (approximately 1 pCi/g).[265] Radium-226 concentrations in U.S. phosphogypsum samples have measured as high as 49 pCi/g.[266] EPA has repeatedly compared phosphogypsum stacks to uranium mill tailing impoundments in both size and radiation exposure.[267] Yet, uranium byproduct materials are managed under standards—in place since 1983—that are identical to Subtitle C standards for hazardous waste treatment, storage and disposal facilities,[268] while state-managed phosphogypsum stack designs, according to EPA, do not even "approach the protectiveness of the uranium mill tailings standards."[269]

B. Process wastewater is a characteristic hazardous waste.

1. Process wastewater exhibits the corrosivity characteristic.

Process wastewater is measured with pH values typically lower than 2, and as extreme as 0.5 (battery acid has a pH of around 1).[270]

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[263] Mosaic Fertilizer, LLC – Uncle Sam Facility, Notice of Critical Condition Pursuant to Attachment E of Appendix 1 to Consent Decree, *United States et al. v. Mosaic Fertilizer*, 15-cv-04889 (Jan. 10, 2019), https://edms.deq.louisiana.gov/app/doc/view.aspx?doc=11478492&ob=yes&child=yes.
[264] Mosaic Fertilizer, LLC, Weekly WebEx Presentation to LDEQ on Uncle Sam Side Slope Lateral Movement at 7 (Jan. 28, 2019), https://edms.deq.louisiana.gov/app/doc/view.aspx?doc=11628070&ob=yes&child=yes.
[265] Report to Congress, *supra* note 27 at 12-7.
[266] EPA, *Potential Uses of Phosphogypsum and Associated Risks, Background Information Document* (1992).
[267] Horton, Thomas (EPA), *A Preliminary Radiological Assessment of Radon Exhalation from Phosphate Gypsum Piles and Inactive Uranium Mill Tailings Piles* at 13 (1979) ("The population . . .exposure within 80 km of a typical Florida phosphate gypsum pile is as great or greater than from a typical inactive uranium mill tailings pile."); EPA, Office of Solid Waste, *Feasibility Analysis: A Comparison of Phosphogypsum and Uranium Mill Tailing Waste Unit Designs* at 9 (1997) ("The uranium mill tailings are a high-volume waste stream that is in some respects analogous to phosphogypsum.").
[268] Uranium mill tailings waste unit design standards are established under the Uranium Mill Tailings Reclamation Act at 40 C.F.R. § 192.
[269] EPA, Office of Solid Waste, *Feasibility Analysis: A Comparison of Phosphogypsum and Uranium Mill Tailing Waste Unit Designs* at 26 (1997) ("[G]ypsum stacks constructed or proposed since the enactment of the 1993 Florida Phosphogypsum Management regulations have followed or exceeded the Florida standards but none of the designs approach the protectiveness of the uranium mill tailings standards.").
[270] Report to Congress, *supra* note 27 at 12-58.

2. Process wastewater exhibits the toxicity characteristic.

Concentrations of cadmium, chromium, and selenium in process wastewater exceeded EP regulatory levels in 1990.[271]

VIII. The RCRA Simpson Amendment affords EPA flexibility in Subtitle C regulation of mineral processing wastes, including phosphogypsum and process wastewater.

All practical difficulties in implementing Subtitle C regulations to such large volumes of waste can be addressed by tailored regulations, or a "Subtitle C minus" program as described in the 1990 report to Congress.[272] Rather than avail itself of this option, EPA has instead opted for no regulation at all.

IX. EPA must initiate prioritization for phosphogypsum and process wastewater as high priority chemical substances for risk evaluation under TSCA §6.

Despite a preference for initiating prioritization for substances listed on the 2014 TSCA Work Plan for Chemical Substances ("work plan"),[273] EPA retains discretion to initiate prioritization for substances not on the work plan, like phosphogypsum and process wastewater from phosphoric acid production, since TSCA regulations require only that 50 percent of the substances currently undergoing risk evaluation are drawn from the work plan.[274] Because EPA indicated almost 30 years ago that phosphoric acid production wastes would be subject to a future TSCA regulatory program, EPA should now initiate their prioritization as high priority substances under the Act.

X. Information necessary to prioritize phosphogypsum and process wastewater is reasonably available.

In order to initiate prioritization, TSCA regulations require only that EPA believe information on relative hazard and exposure potential necessary to prioritize the substance is reasonably available.[275] The information and findings in EPA's 1990 Report to Congress on Special Wastes from Mineral Processing ("Report to Congress") and any supplemental analysis concerning the risks of phosphogypsum and process wastewater to human health and the environment are certainly reasonably available and provide enough information on the risks of these substances to not only initiate prioritization but also to make a high priority designation based on the exposure potential and substantial hazard findings in that report alone, especially when considering that both the size of the stacks and exposed populations have greatly increased since 1990. Once EPA initiates the prioritization process, however, any information EPA has

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[271] The Extraction Procedure test has since been replaced by the more rigorous TCLP test. 40 C.F.R. §261.24(a).
[272] Report to Congress, *supra* note 27 at 12-49.
[273]EPA, *A Working Approach for Identifying Potential Candidate Chemicals for Prioritization* (Sept. 27, 2018) https://www.epa.gov/sites/production/files/2018-09/documents/preprioritization_white_paper_9272018.pdf; 40 C.F.R. § 702.5(c).
[274] 40 C.F.R. § 702.5(c)(2).
[275] 40 C.F.R. § 702.5(a).

obtained or any findings EPA has made, including those in the 1990 Report to Congress, concerning the costs to the industry of certain regulatory, management, or disposal alternatives must not be considered under TSCA as amended by the Lautenberg Act.

A. EPA has already determined that a risk management regulatory program under TSCA §6 is appropriate based on reasonably available information.

As described above, regulation of chemical substances under TSCA involves a three-step process: 1) evaluation of the substance's risk to human health and the environment, without consideration of costs; 2) a determination that the risk is unreasonable; and 3) promulgation of regulations necessary to minimize or manage the unreasonable risk posed by the chemical substance so that the risk is no longer unreasonable. EPA's 1991 Bevill determination not only exempted phosphogypsum and process wastewater from RCRA Subtitle C regulation, it also determined that a TSCA regulatory program was more appropriate, rather than a RCRA Subtitle D program or no regulation at all.[276] Inherent to this determination that TSCA regulation is appropriate is an unreasonable risk determination. EPA's investigation of a TSCA regulatory program to manage phosphogypsum and process wastewater means these substances not only may—but do—pose an unreasonable risk of injury to human health and the environment.

XI. A TSCA §4 testing rule is necessary to fill gaps in current science and to better inform a future risk evaluation.

Rather than study the toxicity, concentration of hazardous constituents at various U.S. phosphogypsum stacks, exposure, and other health and environmental effects relevant to an unreasonable risk finding, the majority of current, published phosphogypsum research is centered on potential commercial uses that are already banned by EPA under the NESHAP due to the risk of widespread radon exposure. With such misdirected science, many people living near a phosphogypsum stack may not even know what the substances in the stack are, let alone the risks they are being subjected to. In this respect, the state-funded Florida Industrial and Phosphate Research Institute, which advocates for a reversal of the limited ban,[277] might as well be a trade association.

Since the 1990 Report to Congress, updated information on population-level exposure risks for radionuclide constituents and radon emissions for phosphogypsum stack systems is necessary, as the population within 80 kilometers of each phosphogypsum stack has likely greatly increased, as well as the number and size of the stacks themselves. Updated toxicity information using the Toxicity Characteristic Leach Procedure (TCLP), which replaced the Extraction Procedure (EP), is also necessary. Should EPA designate phosphogypsum and process wastewater as high-priority substances and conduct a risk evaluation, a testing rule under

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[276] Special Wastes From Mineral Processing (Mining Waste Exclusion); Final Regulatory Determination and Final Rule, 56 Fed. Reg. 27300,56 Fed. Reg. 27300, 27316 (June 13, 1991).
[277] *See* Florida Industrial and Phosphate Research Institute, *Phosphogypsum and the EPA Ban,* http://www.fipr.state.fl.us/about-us/phosphate-primer/phosphogypsum-and-the-epa-ban/) (last visited July 20, 2020).

§4(a)(1)(II)[278] will contribute to the development of information necessary to conduct the risk evaluation.

The need for a §4 testing rule is only further underscored should EPA find that this petition does not set forth sufficient facts to warrant initiation of prioritization. Furthermore, should EPA initiate prioritization but find that the development of new information is necessary to finalize a prioritization decision for phosphogypsum and process wastewater, EPA should exercise its authority under §4(a)(2)(B) to obtain that information and establish priority.

XII. EPA's approval of the use of phosphogypsum in road construction is a significant new use.

On October 20, 2020, the EPA reversed course on its 30+ years of finding that radon from phosphogypsum poses an unacceptable risk to public health if used in road construction and approved the use of phosphogypsum in roads.[279]

In 1992, the EPA finalized its National Emission Standards for Radon Emissions from phosphogypsum stacks finding that "regardless of the radium-226 concentration, the use of phosphogypsum in road construction always resulted in a MIR [(maximum individual risk)] significantly greater than the presumptive safe level….Therefore, EPA has determined that the use of phosphogypsum in road construction presents an unacceptable level of risk to public health."[280] EPA also found that phosphogypsum "contains appreciable quantities of radium-226, uranium, and other uranium decay products…The radionuclides of significance are uranium-238, uranium-234, thorium-230, radon-222, lead-210, polonium-210,"[281] and that these toxins can be resuspended into the air by wind and vehicular traffic. It found that "trace metals may also be leached from phosphogypsum, as are radionuclides, and migrate to nearby surfaces and groundwater resources, that chromium and arsenic may also pose a significant health risk, and that a "number of potential constituents in phosphogypsum from some facilities…may cause adverse effects or restrictions of potential uses of nearby surface and groundwater resources" such as arsenic, lead, cadmium, chromium, fluoride, zinc, antimony, and copper.[282]

The approval authorizes the construction of roads using phosphogypsum with a radium content as high as 35 pCi/g, up to 2.25% phosphogypsum by weight in surface pavement and up to 50% phosphogypsum by weight in the road base.[283]

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[278] 15 U.S.C. § 4(a)(1)(II).
[279] Approval of the Request for Other Use of Phosphogypsum by the Fertilizer Institute, 85 Federal Register 66550 (Oct. 20, 2020).
[280] National Emission Standards for Hazardous Air Pollutants; National Emissions Standards for Radon Emissions from Phosphogypsum Stacks, 57 Fed. Reg. 23305 (June 3, 1992).
[281] EPA, *Potential Uses of Phosphogypsum and Associated Risk, Background Information Document* (1992).
[282] *Id.*
[283] Approval of the Request for Other Use of Phosphogypsum by the Fertilizer Institute, 85 Fed. Reg. 66550, 66552 (Oct. 20, 2020).

XIII. Other Federal Regulatory Programs Are Inadequate to Manage the Risk of Injury to Human Health and the Environment Posed by Phosphogypsum and Process Wastewater

Under TSCA §9, if a chemical substance's risk of injury to human health and the environment is managed effectively under a different statute, regulation under TSCA is not necessary. Section 9 also directs that if EPA determines that a risk to health or the environment associated with a chemical substance or mixture could be eliminated or reduced to a sufficient extent by actions taken under those other federal laws, EPA must use those other laws unless EPA determines it is in the public interest to protect against such risk by actions taken under TSCA.

With the exception of Subtitle C regulation under RCRA, from which phosphogypsum and process wastewater remain Bevill-excluded, other federal regulatory programs remain inadequate to manage the risk of injury to human health and the environment. The EPA has concluded that the Clean Water Act's NPDES permitting requirements govern point source discharges to surface waters, but not groundwaters.[284] The Safe Drinking Water Act's regulations apply only to public water systems, with limited enforcement at the tap. And the Clean Air Act's NESHAP remains minimally protective for radon emissions, containing no prescriptive requirements other than the numerical radon flux standard tested once at the time of closure and imposing no pollution control technology.

XIV. Feasible Alternatives to Current Phosphogypsum and Process Wastewater Management Are Available

Despite EPA's unsupported finding that there are no feasible processes to reduce the toxicity or volume of phosphogypsum and process wastewater production,[285] there are alternatives that EPA can explore after it fully evaluates the risk posed by these substances. These include, without limitation:

- Taking advantage of the high mobility of metal and nonmetal ions in phosphogypsum when leached by implementing a closure technique where the entire stack is rinsed with a "clean" but non-potable water, the leachate collected, and treated.[286]

- Requiring new stack expansions like the 231-acre expansion planned for New Wales to have double geomembrane liners and leak detection leachate systems in place.

- Requiring facilities to use the hemihydrate wet process rather than the dihydrate process, since the hemihydrate process produces less impurities in both the phosphoric acid product and phosphogypsum than the dihydrate process.[287]

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[284] EPA, *Interpretive Statement on the Application of the NPDES Program to Releases of Pollutants from Point Sources to Groundwater*, https://www.epa.gov/sites/production/files/2019-04/documents/interpretative_statement_factsheet_41519.pdf.

[285] *See* Personal Correspondence, *supra* note 95.

[286] Carter, O.C. et al., *supra* note 38 at 200.

[287] EPA, *Background Report AP-42 Section 5.11 Phosphoric Acid* at 4, https://www3.epa.gov/ttn/chief/ap42/ch08/bgdocs/b08s09.pdf.

- Requiring reverse osmosis treatment for stored process wastewater and stack leachate.
- Requiring a soil, synthetic, or artificial turf cover for inactive portions of active stacks.
- Phosphate ore quality control, as the radioactivity of phosphogypsum is dependent on the radium content of the mined phosphate ore itself. Ore producing phosphogypsum with a radium-226 concentration higher than 10 pCi/g should not be mined in the first place.
- Phosphoric acid production limits to limit the amount of phosphogypsum generated.

XV. Conclusion

The damage already caused by phosphogypsum and process wastewater disposal is a consequence of this country's "most dramatic environmental regulatory loophole."[288] EPA's failure to establish specific regulations to control phosphoric acid production wastes as promised under either RCRA or TSCA is now over 30 years in the making. Given the substantial present and potential hazards to human health and the environment posed by these improperly managed wastes, EPA must reverse its Bevill regulatory determination for phosphogypsum and process wastewater and subject these hazardous waste mountains to RCRA Subtitle C regulations. Furthermore, given the magnitude of potential exposure, EPA must begin the prioritization process for a phosphogypsum and process wastewater risk evaluation under TSCA §6 and issue a §4 testing rule to develop information with respect to health and environmental effects relevant to an unreasonable risk finding for disposed phosphogypsum, and a TSCA Significant New Use Rule under §5 for phosphogypsum used in road construction.

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[288] Kloeckner, Jane. 2010. Developing a Sustainable Hardrock Mining and Mineral Processing Industry: Environmental and Natural Resource Law for Twenty-First Century People, Prosperity*, and the Planet,* 25 J. ENVTL. LAW AND LITIGATION 123,131 (quoting *Oversight Hearing to Consider Whether Potential Liability Deters Abandoned HardRock Mine Cleanup: Hearing Before the S. Comm. on Environment and Public Works, 109th Cong. 70* (2006) (statement of Velma M. Smith, Senior Policy Associate, National Environmental Trust)), https://mylaw.uoregon.edu/org/jell/docs/251/kloeckner.pdf.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

May 6, 2021

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

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Dear Ms. Curran and Ms. Lopez:

The U.S. Environmental Protection Agency is responding to the petition filed pursuant to section 21 of the Toxic Substances Control Act, received on February 8, 2021, by you on behalf of the following petitioners: People for Protecting Peace River, Atchafalaya Basinkeeper, Bayou City Waterkeeper, Calusa Waterkeeper, Center for Biological Diversity, Cherokee Concerned Citizens, Healthy Gulf, ManaSota-88, Our Santa Fe River, RISE St. James, Sierra Club's Florida and Delta chapters, Suncoast Waterkeeper, Suwanee Riverkeeper, Tampa Bay Waterkeeper, Waterkeeper Alliance, Waterkeepers Florida, and WWALS Watershed Coalition. The petition requests the EPA to take several actions under section 7004(a) of the Resource Conservation and Recovery Act; section 21 of TSCA; and section 553 of the Administrative Procedure Act related to phosphogypsum and process wastewater. In addition to seeking action under RCRA, the petition asks EPA to (1) initiate the prioritization process for designating phosphogypsum and process wastewater as high priority substances for risk evaluation under TSCA section 6(b)(1)(B)(i), (2) issue a test rule under TSCA section 4(a)(1)(A) requiring phosphogypsum and process wastewater manufacturers to develop information with respect to health and environmental effects relevant to a determination that the disposal of these chemical substances does or does not present an unreasonable risk of injury to health or the environment, and (3) make a determination by rule under TSCA section 5(a) that the use of phosphogypsum in road construction is a significant new use.

Because TSCA section 21 only provides for petitions for EPA to initiate a rulemaking proceeding for the issuance, amendment, or repeal of a rule under TSCA sections 4, 6, or 8, or an order under TSCA sections 4 or 5(e) or (f), EPA is only addressing the request for the issuance of a TSCA section 4 test rule under TSCA section 21 and is considering the requests for action under TSCA sections 5(a) and 6(b)(1)(B)(i) as petitions for action under the APA. This response letter specifically addresses the portion of the petition under TSCA section 21, not the portions of the petition under the APA, or under section 7004(a) of RCRA.

As a general matter, EPA shares the petitioners' concern regarding the potential for disproportionate impacts in communities with environmental justice concerns.

EPA has reviewed the information submitted in your petition. Based on this review and after careful consideration of your specific requests, EPA is denying the request to initiate a proceeding for the issuance of a rule under TSCA section 4 because the TSCA section 21 petition does not set forth the facts establishing that it is necessary for the Agency to issue such a rule. The Agency's reasons for denying this portion of the petition will be published in a forthcoming edition of the *Federal Register*. A pre-publication copy of that *Federal Register* document is enclosed.

Under TSCA section 21, the petitioners have the right to appeal the Agency's denial of its petition by commencing a civil action in a U.S. district court to compel initiation of the requested proceeding within 60 days of a denial. If you would like to discuss this matter further, please contact Tanya Hodge Mottley, Director, Existing Chemicals Risk Management Division, Office of Chemical Safety and Pollution Prevention, at (202) 564-3152 or by email at mottley.tanya@epa.gov.

Sincerely,

MICHAL FREEDHOFF
Digitally signed by MICHAL FREEDHOFF
Date: 2021.05.06 20:12:53 -04'00'

Michal Freedhoff, Ph.D.
Principal Deputy Assistant Administrator

Enclosure

CENTER for BIOLOGICAL DIVERSITY *Because life is good.*

Submitted via e-mail and certified mail

April 15, 2024

The Honorable Michael Regan, Administrator
Environmental Protection Agency
1200 Pennsylvania Ave. NW
Washington, DC 20460
Regan.Michael@epa.gov

Re: Notice of Intent to Sue for Failure to Perform a Nondiscretionary Duty under the Resource Conservation and Recovery Act

Dear Administrator Regan,

On February 13, 2024, we sent you official notice that the Center for Biological Diversity, People for Protecting Peace River, Bayou City Waterkeeper, Healthy Gulf, Manasota-88, Our Santa Fe River, Portneuf Resource Council, RISE St. James, Sierra Club, Waterkeeper Alliance, and Waterkeepers Florida (*hereinafter* "Conservation Organizations") intend to file a lawsuit against you and the United States Environmental Protection Agency (EPA) for failure to perform a nondiscretionary duty under the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. § 6901, *et seq*.[1] Due to a United State Postal Service error and EPA's failure to subsequently confirm receipt of said notice upon request[2], this letter serves to renew and replace that official notice and provides additional information concerning recent developments that have occurred between February 13, 2024 and the date of this notice.

As further specified below, you have violated your mandatory duty under 42 U.S.C. § 6974(a) to "take action" within a "reasonable time" on the Conservation Organizations' petition requesting the EPA promulgate regulations to address the threat of phosphogypsum waste and process wastewater from phosphoric acid production.[3] Should this violation remain unresolved after 60 days, the Conservation Organizations intend to seek relief compelling EPA's compliance and recovering attorneys' fees and other costs of litigation.

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[1] Notice is provided 42 U.S.C. § 6972(c) to the extent deemed necessary by a court.
[2] Ragan Whitlock e-mail correspondences with various EPA staff (Feb. 13, 2024, 10:53 AM EST – Apr. 2, 2024, 01:38 PM EST).
[3] People for Protecting Peace River et al., Petition for Rulemaking Pursuant to Section 7004(A) of the Resource Conservation and Recovery Act; Section 21 of the Toxic Substances Control Act; and Section 553 of the Administrative Procedure Act Concerning the Regulation of Phosphogypsum and Process Wastewater from Phosphoric Acid Production dated Feb. 8, 2021 [hereinafter Petition for Rulemaking], https://www.biologicaldiversity.org/campaigns/phosphate_mining/pdfs/2021_02_08-PG-petition-to-EPA-TSCA-RCRA.pdf.

I. INTRODUCTION

Phosphogypsum is radioactive, corrosive, toxic waste that threatens surface waters, drinking waters, clean air, communities, and the environment throughout the United States. The fertilizer industry generates phosphogypsum when it chemically digests phosphate rock with sulfuric acid to create phosphoric acid for fertilizer.[4] This method of producing phosphoric acid also creates process wastewater, which is stored with the phosphogypsum in dangerous man-made waste mountains known as phosphogypsum stacks or "gypstacks."[5] Phosphogypsum and its leachate contain several toxic constituents that the EPA has determined present a hazard to human health and the environment, including arsenic, lead, nickel, cadmium, fluoride, chromium, silver, antimony, copper, mercury, thallium, and radionuclides.[6] Process wastewater contains all of these toxic constituents as well as selenium, with toxicity at or above characteristic regulatory levels for selenium, cadmium, and chromium.[7] Process wastewater is also highly acidic and corrosive with pH values typically lower than 2 and sometimes as low as 0.5.[8]

By its own account, the fertilizer industry generates 46 million tons of harmful and radioactive phosphogypsum waste annually, significantly more than the combined total of all regulated hazardous waste produced by all generators in the nation.[9] More than 1 billion tons of phosphogypsum are already stored across 25 stacks systems in Florida alone.[10] A consolidated domestic phosphate fertilizer industry — just three powerful fertilizer companies[11] — continues to dump its massive waste burden onto the public, stacking it up in mountainous open-air piles hundreds of feet tall and hundreds of acres wide.[12]

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[4] EPA, Report to Congress on Special Wastes from Mineral Processing (1990) at 12-1 [hereinafter Report to Congress].
[5] *TENORM: Fertilizer and Fertilizer Production Wastes*, EPA, https://www.epa.gov/radiation/tenorm-fertilizer-and-fertilizer-production-wastes (last visited Mar. 28, 2024).
[6] Chromium often tests above toxicity characteristic regulatory levels. Report to Congress, *supra* note 4, at 12-7 – 12-8.
[7] *Id*. at 12-4.
[8] *Id.* at 12-58; Supplemental Information on Phosphoric Acid Production, EPA (Dec. 1990) at 6 ("the Agency believes that the source of the dissolved metals in process wastewater that have been observed at some facilities is phosphogypsum, and that the potential for dissolution and release of these metals is greatly increased through the more or less constant exposure of the gypsum to the highly acidic process wastewater that circulates through active gypsum disposal areas (phosphogypsum stacks) and is returned to the cooling water pond").
[9] The Fertilizer Institute, Revised Request for Approval of Additional Uses of Phosphogypsum Pursuant to 40 C.F.R. § 61.206 (2020) at 6, https://www.epa.gov/sites/default/files/2020-10/documents/4-7-2020_pg_petition.pdf, compare with National Biennial RCRA Hazardous Waste Report, EPA (2021), https://rcrapublic.epa.gov/rcrainfoweb/action/modules/br/summary/summarysearch (last visited Mar. 28, 2024).
[10] Francisco Macías et al., *Environmental Assessment and Management of Phosphogypsum According to European and United States of America Regulations*, 17 Procedia Earth & Planetary Sci. 666, 667 (2017).
[11] Mike Nash, *Just how consolidated is fertilizer supply globally?* ARGUS MEDIA, https://www.argusmedia.com/-/media/Files/white-papers/2020/2020-12-argus-wp-just-how-consolidated-is-fertilizer-supply-globally.ashx (2020); The Fertilizer Institute, Petition for Additional Use of Phosphogypsum, Appendix 7 (Feb. 2020), https://www.epa.gov/sites/default/files/2020-10/documents/appendix_7_-_location_of_pg_stacks_0.pdf.
[12] EPA, TENORM: Fertilizer and Fertilizer Production Wastes, *supra* note 5; EPA, Major Fertilizer Producer Mosaic Fertilizer, LLC to Ensure Proper Handling, Storage and Disposal of 60 Billion Pounds of Hazardous Waste / Manufacturer committing close to $2 billion in funding to address environmental impacts (Oct. 1, 2015), https://www.epa.gov/enforcement/major-fertilizer-producer-mosaic-fertilizer-llc-ensure-proper-handling-storage-and (last visited Mar. 28, 2024).

More than three decades ago, just prior to exempting phosphogypsum and process wastewater from hazardous waste regulation, the EPA correctly predicted that the industry would expand, increasing its hazard and contaminant release potential.[13] At the time, the EPA believed it would need to address phosphogypsum and process waster's anticipated harms via emergency authorities through site-specific abatement actions and through development of an alternative federal regulatory regime under the Toxic Substances Control Act (TSCA).[14] The agency also promised it would revisit its Bevill regulatory determination for phosphogypsum and process wastewater if it found during its TSCA regulatory investigation that RCRA could better handle the problem.[15] But EPA has done none of that. Instead, for the last 30 years while the industry has continued to grow its dangerous waste inventory as predicted, EPA has intervened only to designate one additional phosphogypsum stack facility as a Superfund site,[16] and to negotiate settlements with individual fertilizer companies for the widespread illegal mixing of non-exempt hazardous waste with Bevill-exempt phosphogypsum and process wastewater in phosphogypsum stacks.[17]

Conservation Organizations have members that live in communities within the shadows of these toxic mountains. On February 8, 2021 they reminded EPA of its broken promises and petitioned the agency to initiate a rulemaking under RCRA to revisit its 1991 Bevill regulatory determination as to phosphogypsum and process wastewater and list them as hazardous wastes.[18] Nearly three years later — enough time to see new liner tears in phosphogypsum stacks,[19]

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[13] EPA, Report to Congress on Special Wastes from Mineral Processing at 12-59 (1990). [hereinafter Report to Congress].

[14] Final Regulatory Determination for Special Wastes from Mineral Processing (Mining Waste Exclusion), 56 Fed. Reg. 27300, 27300 (June 13, 1991) [hereinafter 1991 Bevill determination].

[15] *Id.* at 27316; EPA, Risks Posed by Bevill Wastes at 7 (1997), https://archive.epa.gov/epawaste/hazard/web/pdf/risks.pdf (last visited Mar. 28, 2024).

[16] EPA has listed two phosphogypsum stack sites on the National Priorities List since EPA's 1991 Bevill determination, designating at least four phosphogypsum stacks as Superfund sites in total: 1) Bunker Hill in northern Idaho and the Couer d' Alene Reservation, listed in 1983. EPA, Bunker Hill Mining and Metallurgical Complex, Smelterville, ID, https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.docdata&id=1000195 (last visited Mar. 28, 2024); 2) Eastern Michaud Flats in Pocatello, Idaho, listed in 1990. EPA, Eastern Michaud Flats Contamination, https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.cleanup&id=1001308#bkground (last visited Mar. 28, 2024); 3) Depue/ New Jersey Zinc/ Mobil Chemical Corp. in Depue, IL, listed in 1999. EPA, Declaration of Record of Decision - New Jersey Zinc/Mobile Chemical Corp. National Priorities List Site dated Oct. 3, 2003; and 4) Mississippi Phosphates Corporation in Pascagoula, MS, listed in 2018. EPA, Mississippi Phosphates Corporation, Pascagoula, MS, https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0403508 (last visited Mar. 28, 2024).

[17] Department of Justice, Major Fertilizer Producer Mosaic Fertilizer, LLC to Ensure Proper Handling, Storage and Disposal of 60 Billion Pounds of Hazardous Waste (Oct. 1, 2015 (last visited Mar. 28, 2024); Department of Justice, Justice Department Announces Settlement with J.R. Simplot to Improve Hazardous Waste Management and Reduce Emissions at Idaho Facility July 11, 2023 (last visited Mar. 28, 2024); Department of Justice, Settlement with PCS Nitrogen Fertilizer to Require Treatment of More Than a Billion Pounds of Hazardous Waste and Closure of Huge Phosphogypsum Waste Stacks and Impoundments (July 14, 2022 (last visited Mar. 28, 2024).

[18] Petition for Rulemaking, *supra* note 3.

[19] See, e.g., Notices of Critical Condition, FDEP Facility ID MMR_FL0036421, Mosaic New Wales); Notices of Critical Condition, FDEP Facility ID MMR_FL000761 (Mosaic Riverview) (last visited Mar. 28, 2024).

phosphogypsum stack geologic instability,[20] at least one new potential sinkhole,[21] and the near-collapse of the Piney Point NGS-S impoundment[22] — EPA continues to delay even responding to the petition for rulemaking. And while EPA delays and the phosphogypsum stacks lurch beyond their containment capacity, the fertilizer industry continues to construct phosphogypsum stack expansions and pursue dangerous *additional* – not alternative – disposal methods into roadways and aquifers.[23] In light of the broken promises and ongoing, expanding risks to human health and the environment, these delays are egregious and unreasonable.

II. ENTITIES GIVING NOTICE

People for Protecting Peace River seeks to educate the public and fight for the extraordinary natural and agricultural lands and waterways of interior Florida. The goal of 3PR is to stop the damage by phosphate strip mining and fertilizer production.

Bayou City Waterkeeper protects the waters and people across the greater Houston region through bold legal action, community science, and creative, grassroots policy to further justice, health, and safety for our region.

Center for Biological Diversity is a national, nonprofit conservation organization with more than 1.7 million members and online activists dedicated to the protection of endangered species and the habitat and climate they need to survive. We believe that the welfare of human beings is deeply linked to nature — to the existence in our world of a vast diversity of wild animals and plants. Because diversity has intrinsic value, and because its loss impoverishes society, we work to secure a future for all species, great and small, hovering on the brink of extinction. We do so through science, law and creative media, with a focus on protecting the lands, waters and climate that species need to survive.

Healthy Gulf is a nonprofit organization dedicated to protecting and restoring the natural resources of the Gulf of Mexico. Since 1994, Healthy Gulf's mission has been to collaborate with and serve communities who love the Gulf of Mexico by providing the research, communications, and coalition-building tools needed to reverse the long pattern of over-exploitation of the Gulf's natural resources.

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[20] Center for Biological Diversity, Letter to EPA RE: EPA Must Take Immediate Action to Prevent an Imminent Environmental Emergency at the Country's Largest Phosphogypsum Stack (July 21, 2022.

[21] FDEP, Wastewater Compliance Inspection Report, Mosaic New Wales Concentrates Plant dated Oct. 20, 2023.

[22] Bryan Pietsch and Marie Fazio, New York Times, Imminent Collapse of Wastewater Reservoir in Florida Forces Evacuations dated April 3, 2021, https://www.nytimes.com/2021/04/03/us/piney-point-phospate-plant-state-of-emergency.html (last visited Mar. 28, 2024).

[23] Mosaic Fertilizer, LLC, Revised Request from The Mosaic Company for Use of Phosphogypsum in Road Construction Pilot (Aug. 23, 2023), https://www.epa.gov/system/files/documents/2023-09/Mosaic%20PG%20Pilot%20Road%20Revised%20Request%208-23-23.pdf; Mosaic Fertilizer, LLC, Request for Approval of Additional Uses of Phosphogypsum Pursuant to 40 C.F.R. § 61.206, Small-scale Road Pilot Project on Private Land in Florida (Mar. 31, 2022), https://www.epa.gov/system/files/documents/2023-09/2.1%20Final%20Mosaic%20Small-Scale%20Road%20Pilot%20Study%203-31-2022_.pdf; The Fertilizer Institute, Revised Request for Approval of Additional Uses of Phosphogypsum Pursuant to 40 C.F.R.§61.206 (Apr. 7 2020), https://www.epa.gov/sites/default/files/2020-10/documents/4-7-2020_pg_petition.pdf; Mosaic Fertilizer, LLC, Initial Application to Construct Class I Injection Well System Hillsborough County dated Oct. 17, 2023.

ManaSota-88 is a not-for-profit public health, conservation, and environmental protection organization. The corporate purposes of ManaSota-88 include the protection and preservation of water quality and wildlife habitat in Florida.

Our Santa Fe River's mission is to protect the aquifer, springs, and rivers within the watershed of the Santa Fe River.

The Portneuf Resource Council (PRC) is committed to helping build sustainable environmental communities that balance economic growth with the health of people and stewardship of their environment. Our focus is in the Portneuf River Valley, the city of Pocatello and its surrounding communities. We are actively engaged in Climate Solutions and Clean Water initiatives.

The mission of RISE St. James is to fight petrochemical industry in St. James Parish and throughout the River Parishes that continue to poison the air we breathe, water we drink and soil we need. To reclaim our community, to create a brighter future to inspire others. To rise above the broken promises fostered by misinformation and corporate greed and to preserve the rich culture and tradition of our parish, state and region.

The Sierra Club is America's largest and most influential grassroots environmental organization, with more than 3.8 million members and supporters. In addition to protecting every person's right to get outdoors and access the healing power of nature, the Sierra Club works to promote clean energy, safeguard the health of our communities, protect wildlife, and preserve our remaining wild places through grassroots activism, public education, lobbying, and legal action.

Waterkeeper® Alliance is a global movement uniting more than 300 community-based Waterkeeper Organizations and Affiliates around the world, focusing citizen action on issues that affect our waterways, from pollution to climate change. The Waterkeeper movement patrols and protects over 2.75 million square miles of rivers, lakes, and coastlines in the Americas, Europe, Australia, Asia, and Africa.

Waterkeepers Florida is a regional entity composed of all 15 Waterkeeper organizations working in the State of Florida to protect and restore our water resources across over 45,000 square miles of watershed, which is home to over 15 million Floridians. Part scientist, teacher, and legal advocate, Waterkeepers combine firsthand knowledge of their waterways with an unwavering commitment to the rights of their communities and to the rule of law. Whether on the water, in a classroom, or in a courtroom, Waterkeepers speak for the waters they defend – with the backing of their local community and the collective strength of Waterkeeper Alliance.

III. REGULATORY FRAMEWORK

Congress enacted RCRA in 1976 to address the growing problem of municipal and industrial waste and to "promote the protection of health and the environment and to conserve valuable material and energy resources."[24] Subtitle C of RCRA establishes the "cradle to grave" system,

[24] 42 U.S.C. § 6902(a).

meaning that hazardous waste is managed safely from the time it is created to its disposal. "Hazardous wastes" are defined as any discarded material:

> which because of its quantity, concentration characteristics, or physical, chemical or infectious characteristics may—
>
> (A) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or
>
> (B) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.[25]

In 1980, Congress passed the Bevill amendment to RCRA, which exempted 20 categories of "special wastes," like mining and mineral processing wastes, from regulation under Subtitle C and required the EPA to complete a full assessment of each exempted waste and to submit a full report to Congress on the findings.[26]

In 1990, the EPA completed its study of phosphogypsum and submitted it to Congress.[27] The report identified widespread groundwater contamination near phosphogypsum stacks, contaminated off-site wells and drinking water sources, and an increased risk for air pathway cancer for those living near stacks.[28] The report also identified an increased risk of containment release potential for phosphogypsum and phosphoric acid production process wastewater (process wastewater) if the phosphate mining industry were to continue to expand without Subtitle C regulation.[29]

Despite the risks outlined in this report, the EPA published its Bevill determination for the special wastes in 1991, stating that regulation under Subtitle C of RCRA would be "inappropriate" for phosphoric acid processing wastes, citing the costs to the industry if required to adhere to Subtitle C.[30] Instead, the EPA announced its intention to regulate these wastes under the Toxic Substances Control Act (TSCA).[31] The 1991 Bevill determination also stated that if more information became available indicating that RCRA is best suited to regulate phosphogypsum and process wastewater, EPA would revisit its 1991 Bevill determination.[32] However, to date, the EPA has not promulgated any rules under the TSCA for phosphogypsum or process wastewater nor has it revisited its 1991 Bevill determination.

Under section 6974(a) of RCRA, "any person may petition the Administrator for the promulgation, amendment, or repeal of any regulation under this chapter."[33] The Administrator is

[25] 42 U.S.C. § 6903(5).
[26] Solid Waste Disposal Act Amendments of 1980, Public Laws 96-482, 42 U.S.C. § 6921.
[27] Report to Congress, *supra* note 4, at 27.
[28] *Id*.
[29] *Id.*
[30] 1991 Bevill determination, *supra* note 14, at 12.
[31] *Id.*
[32] *Id*. at 17.
[33] 42 U.S.C. § 6974(a).

compelled to answer "within a reasonable time following receipt of such petition."[34] Additionally, under the Administrative Procedure Act (APA), agencies are required to conclude a matter presented to it in "reasonable time."[35] The APA also authorizes reviewing courts to compel agency action "unlawfully withheld or unreasonably delayed."[36]

Under section 7002 of RCRA, any person may commence a civil action "against the Administrator where there is alleged a failure to perform any act or duty under this chapter which is not discretionary with the Administrator."[37] Responding to the 2021 Petition is a nondiscretionary task that the Administrator must undertake within a "reasonable time."[38]

IV. <u>EPA'S RCRA & APA VIOLATIONS</u>

EPA has unreasonably delayed responding to Organizations' February 8, 2021, petition for a rulemaking that would reverse EPA's 1991 Bevill determination for phosphogypsum and process wastewater, and list the wastes as hazardous wastes subject to Subtitle C.[39]

In the three years since the EPA received the 2021 Petition, several phosphogypsum spills and releases posing substantial hazards to human health and the environment have occurred. This includes a devastating intentional release of millions of gallons of process water mixed with dredge waste and rainwater into Tampa Bay to avoid the catastrophic collapse of the Piney Point Phosphate Processing Facility (Piney Point)[40] and ongoing seismic and sinkhole activity at the New Wales phosphogypsum stack.[41]

An agency's delay is unreasonable where the delay is not guided by a "rule of reason," the delay is contrary to the statutory scheme, there are significant risks to human health and welfare, the agency does not have higher competing priorities, or where the nature of the interests prejudiced by delay are significant.[42] A showing of bad faith is not required to demonstrate a delay has been unreasonable.[43]

The EPA's delay in responding to the 2021 petition is unreasonable as it is not guided by the rule of reason, it frustrates the purpose of RCRA, threatens significant harm to human health and the environment, and prejudices impacted communities.

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[34] *Id*.
[35] 5 U.S.C. § 555(b).
[36] 5 U.S.C. § 706(1).
[37] 42 U.S.C. § 6972(a)(2).
[38] 42 U.S.C. § 6974(a).
[39] Risks Posed by Bevill Wastes, *supra* note 15 at 7; Petition for Rulemaking, *supra* note 2.
[40] FDEP, Emergency Final Order No. 21-0323 (Mar. 29, 2021), https://floridadep.gov/sites/default/files/21-0323.pdf (last visited Mar. 28, 2024); Governor Ron DeSantis, Executive Order 21-82 (April 3, 2021) https://www.flgov.com/wp-content/uploads/orders/2021/EO_21-82.pdf (last visited Mar. 28, 2024).
[41] Ardaman & Associates, Letter to Santino Provenzano Re: Confirmed Critical Condition at Area of Interest 4, New Wales Plant South Gypsum Stack (SGS), Phase II West-North Area, Mosaic Fertilizer, LLC, New Wales Facility, Polk County, Florida (December 14, 2023).
[42] *Telecomms. Research and Action Ctr. v. Fed. Commc'ns Research and Action Ctr*., 750 F. 2d 70, 80 (D.C. Cir. 1984); *Cmty. Voice v. EPA*, 878 F. 3d 779, 784-86 (9th Cir. 2017).
[43] *Id*.

A. The EPA's delay is not guided by the rule of reason.

The most important factor in determining whether an agency's delay is unreasonable is whether the delay falls outside the rule of reason; here, EPA's delay in taking action on the RCRA provisions of the 2021 Petition is not guided by the rule of reason.[44] Where a statute indicates "the speed with which it expects the agency to proceed…that statutory scheme may supply content for this rule of reason."[45] The rule of reason is also influenced by the complexity of the task, the significance and permanence of the outcome, and the resources that are available to the agency.[46] RCRA explains EPA must reply to petitions for rulemaking "within a reasonable time following receipt of such petition."[47]

In measuring whether the agency's delay is consistent with the rule of reason, the relevant inquiry is: *When did the agency first come under a duty to act?*[48] Here, the EPA has been under a duty to act on the regulation of phosphogypsum since it first recognized phosphogypsum and process wastewater have unaddressed environmental and health concerns more than 30 years ago. In 1991, when EPA determined all of the mining and mineral processing special wastes would retain their temporary Bevill exemption from Subtitle C regulation, the EPA instead planned to develop a RCRA Subtitle D solid waste program with waste-specific tailored minimum federal guidelines to address the remaining risks posed by 18 of the 20 exempt mining and mineral processing special wastes.[49] However, EPA specifically identified the other two special wastes — phosphogypsum and process wastewater — as having more unaddressed risks requiring more regulation than the rest.[50] In acknowledging that a tailored Subtitle D program for phosphogypsum and process wastewater would be insufficient and that there was a "need for action to address the risks,"[51] EPA announced a two-pronged approach: first, EPA would address site-specific phosphogypsum and process wastewater groundwater contamination problems by relying on authorities under RCRA §7003 or the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) §106; and second, instead of a tailored Subtitle D program, EPA would develop a regulatory program under the TSCA for phosphogypsum and process wastewater.[52] However, the EPA later determined in 1997 that regulation for phosphogypsum and process wastewater would not be possible under TSCA, acknowledging that it must revisit the 1991 Bevill determination to evaluate if the exclusion remained appropriate.[53]

Over 30 years have elapsed since the initial Bevill determination, the EPA has never revisited the Bevill determination, and the phosphate industry has continued to dangerously expand. Even assuming arguendo that the EPA did not come under a duty 30 years ago when it determined

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[44] *Id*.
[45] *In re: United Mine Workers of Am. Int'l Union*, 190 F.3d 545, 549 (D.C. Cir. 1999) (quoting *TRAC*, 750 F.2d at 80).
[46] *Sarlak v. Pompeo*, No. 20-35, 2020 WL 3082018, at *6 (D.D.C. Jun. 10, 2020); *Mashpee Wampanoag Tribal Council, Inc. v. Norton*, 336. F.3d 1094, 1102 (D.C. Cir. 2003).
[47] 42 U.S.C. § 6974(a).
[48] *Biodiversity Legal Found. v. Norton*, 285 F. Supp. 2d 1 (D.D.C. 2003) (finding that the U.S. Fish and Wildlife Service was under a duty to act years before a petition was received for revising critical habitat).
[49] 1991 Bevill determination, *supra* note 14.
[50] *Id.*
[51] *Id.* at 27316
[52] *Id.*
[53] Risks Posed by Bevill Wastes, *supra* note 15, at 7.

additional regulation to address remaining risks after the exemption was necessary, it certainly came under a duty to act when it received the 2021 Petition. This three-year delay does not fall under a rule of reason,[54] particularly in light of ongoing critical phosphogypsum stack failures since 2021.

1. Delay in light of the Piney Point disaster is unreasonable.

The 2021 Petition detailed major releases of phosphogypsum to surface and groundwater that occurred since the EPA last comprehensively reviewed phosphogypsum in 1990.[55] Shortly after EPA received the 2021 Petition, Florida officials ordered the discharge of hundreds of millions of gallons of water from the top of the Piney Point phosphogypsum stack into Tampa Bay to avert a catastrophic collapse that threatened to send a wall of phosphogypsum and wastewater onto the nearby community.[56] Florida Governor Ron DeSantis declared a state of emergency for the surrounding counties and over 300 homes and the Manatee County Jail were evacuated.[57] The wastewater discharge into Tampa Bay contained high levels of inorganic nutrients,[58] including 186 metric tons of nitrogen, which, in just one release event, far exceeded the typical total external nitrogen load estimates for all of the Bay in any given year.[59] The discharge of Piney Point wastewater fueled one of the worst red tide events the area has experienced in 50 years, killing so much marine life that the death toll could only be measured in tonnage of dead flesh and bone (600 tons in Tampa Bay alone).[60] Red tide produces brevetoxins that can kill fish, birds and other marine species, and harms human health by causing respiratory irritation.[61]

Not only did the 2021 Piney Point disaster cause irreparable harm shortly after Conservation Organizations submitted their unanswered petition to EPA, it also opened the door for unchecked

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[54] *Pub. Citizen Health Research Group v. Auchter*, 702 F.2d 1150, 1154 (D.C. Cir. 1983) (holding a three-year delay in responding to a petition for the regulation of ethylene oxide was unlawful); *Pub. Citizen Health Research Group v. Comm'r, Food & Drug Admin*., 740 F.2d 21, 35 (D.C. Cir. 1984) (finding that a two year delay in responding to a petition was "unreasonably dilatory" when lives were at stake due to the nature of the petition.).
[55] Petition for Rulemaking, *supra* note 3, at 33-35.
[56] Kimberly Kuzion, *Breach at Piney Point would pose 'significant danger to environmental and public health.'* FOX 13 NEWS (updated Apr. 1, 2021), https://www.fox13news.com/news/breach-at-piney-point-poses-significant-danger-to-environmental-and-public-health (last visited Mar. 28, 2024); Bethany Barnes et al., *Failure at Piney Point: Florida let environmental risk fester despite warnings*, TAMPA BAY TIMES (Apr. 17, 2021), https://www.tampabay.com/news/environment/2021/04/17/failure-at-piney-point-a-disaster-foretold/ (last visited Mar. 28, 2024).
[57] *Governor Ron DeSantis Provides Update on Piney Point, Meets with DEP and FDEM Leadership, Local Officials and Emergency Response Teams*, FLGOV (Apr. 4, 2021), https://www.flgov.com/2021/04/04/governor-ron-desantis-provides-update-on-piney-point-meets-with-dep-and-fdem-leadership-local-officials-and-emergency-response-teams/ (last visited Mar. 28, 2024).
[58] Elise S. Morrison et al., *The response of Tampa Bay to a legacy mining nutrient release in the year following the event*, 11 FRONTIERS ECOLOGY AND EVOLUTION at 2 (2023), https://www.frontiersin.org/articles/10.3389/fevo.2023.1144778/full.
[59] Marcus Beck et al., *Initial estuarine response to inorganic nutrient inputs from a legacy mining facility adjacent to Tampa Bay, Florida*, 178 FLA. POLLUTION BULLETIN at 2 (2022), https://doi.org/10.1016/j.marpolbul.2022.113598.
[60] Lauren M. Johnson, *Large red tide in Tampa, Florida, has contributed to over 600 tons of dead fish*, CNN (July 19, 2021), https://www.cnn.com/2021/07/19/us/red-tide-kills-marine-life-tampa-trnd/index.html (last visited Apr. 12, 2024).
[61] *Id*.

state and local regulators to permit, for the first time in Florida,[62] the injection of process wastewater – which could be regulated hazardous waste but for EPA's flawed 1991 Bevill determination – into a newly constructed Class I Underground Injection Control Well (UIC) below the Floridan aquifer.[63] Even though Florida UIC wells have a history of failing,[64] this permit moved forward without an extensive study of migration potential required for an exemption from RCRA's land disposal restrictions prohibiting deep well injection of many hazardous wastes, including listed and characteristic mineral processing wastes.[65] This "out-of-sight, out-of-mind" means of discarding dangerous waste also undermines Florida's longstanding statutory prohibition on new hazardous waste Class I UIC wells, enacted specifically to protect contamination-prone groundwater within Florida's delicate karst geology.[66]

2. Delay in light of sink holes and structural problems at New Wales is unreasonable.

At Mosaic's New Wales facility in Mulberry, Florida, the gypstacks have also been experiencing significant structural challenges. The New Wales facility generates approximately 8 million tons of phosphogypsum per year.[67] New Wales sits atop karst, soluble carbonic rock prone to sinkholes, and has suffered massive sinkholes, geologic anomalies, and liner tears at both of its phosphogypsum stacks, including a sinkhole in 1994 and sinkhole-like geologic anomalies in 2004 and 2013.[68] The most recent confirmed and reported sinkhole at New Wales occurred in 2016 and caused 215 million gallons of acidic process wastewater and an unknown quantity of radioactive phosphogypsum to collapse into the Floridan aquifer.[69] That toxic waste likely remains in the aquifer to this day, even as Mosaic continues to pump from recovery wells over seven years later in an attempt to recover contaminated groundwater.[70] An independent study

[62] Mosaic's laterally shifting Uncle Sam facility constructed upon unstable soils in St. James Parrish, Louisiana has been injecting process wastewater underground since 2014. LDEQ, *Mosaic Uncle Sam Final Approval of the Petition for Determinations Concerning No-Alternative to Land Disposal of a Prohibited Waste by Deepwell Injection* (Mar. 26, 2014).
[63] Jesse Mendoza, *Injection of Polluted Wastewater from Piney Point Underground Begins in Manatee County, Sarasota Herald-Tribune* (Apr. 6, 2023), https://www.heraldtribune.com/story/news/environment/2023/04/06/underground-injection-of-piney-point-wastewater-begins-in-manatee/70079416007/ (last visited Mar. 28, 2024); FDEP, Notice of Permit, Class I Injection Well System, IW-1, DEP UIC Permit No: 0322708-002-UC/1I (Dec. 16, 2021).
[64] Abrahm Lustgarten, *Injection Wells: The Poison Beneath, Us* PROPUBLICA dated June 21, 2012 (last visited Mar. 28, 2024).
[65] 40 C.F.R §148.20; 40 C.F.R. 148.18(a). EPA found in 1990 that many phosphoric acid facilities were producing characteristic (toxicity and/or corrosivity) hazardous phosphogypsum and process wastewater. 1990 Report to Congress at 12-48.
[66] § 403.7222, Fla. Stat.; *see also* Wade L. Hopping & William D. Preston, *The Water Quality Assurance Act of 1983 – Florida's "Great Leap Forward" into Groundwater Protection and Hazardous Waste Management*, 11 FLA. ST. U. L. REV. 599, 603-05 (1983).
[67] The facility generates 8,0000 tons per year of phosphogypsum annually at a rate of 5.62 tons of waste per ton of phosphoric acid. Ardaman & Associates, Inc. on behalf of Mosaic, FDEP Construction Operation Permit Application and Supporting Engineering Report Phase IV Gypsum Stack Extension, Mosaic New Wales (Feb. 15, 2024) at 4.
[68] Petition for Rulemaking, *supra* note 3 at 24-25.
[69] Christopher O'Donnell, *Mosaic plant sinkhole dumps 215 million gallons of reprocessed water into Floridan Aquifer*, TAMPA BAY TIMES (Sept. 16, 2016), https://www.tampabay.com/news/environment/water/mosaic-plant-sinkhole-dumps-215-million-gallons-of-reprocessed-water-into/2293845/ (last visited Mar. 28, 2024).
[70] FDEP Application Phase IV Gypsum Stack Extension, Mosaic New Wales, *supra* note 67, Table 1-7 at 1-23.

found "there is uncertainty in the fate of the contaminant waste after the sinkhole collapse."[71] Despite this history, and since the date Conservation Organizations' petition while EPA delays a response , the Florida Department of Environmental Protection (FDEP) authorized a 231-acre expansion of New Wales on October 15, 2021 and is currently considering yet another expansion of 289 acres as of February 15, 2024.[72] In 2022, again after Conservation Organizations submitted their petition for rulemaking and while EPA delayed and continues to delay a response, seismic activity beneath the active phosphogypsum stack temporarily halted stack these expansion activities.[73] In June 2022, FDEP confirmed a liner tear and void formation that the FDEP believed "has the potential to develop into a sinkhole."[74] In October 2023, another geologic anomaly and potential liner tear occurred at New Wales, resulting in an unquantified volume of process wastewater loss incident there.[75] Months later in December of 2023, Mosaic's consultants confirmed a liner tear within the phosphogypsum stack but did not appear to disclose the volume of process wastewater "lost" to groundwater.[76]

The disaster at Piney Point and the ongoing issues at New Wales illustrate the dangers of EPA's under-regulation of phosphogypsum and demonstrate that the EPA is not acting under a rule of reason in delaying action on the 2021 Petition. The rule of reason dictates that EPA move quickly to adequately regulate this growing waste problem rather than further delay a response.

B. The EPA's delay in responding to the 2021 Petition frustrates the purposes of RCRA and threatens significant harm to human health and the environment.

The EPA's delay in responding to the 2021 Petition frustrates the purposes of RCRA, which are to reduce the amount of solid waste generated and to ensure that these wastes are managed in an environmentally sound manner that protects human health and the environment from the potential hazards of waste disposal.[77] When an agency's delay has a significant impact on human health, it is very likely that it is unreasonable. "Delays that might be reasonable in the sphere of economic regulations are less tolerable when human health and welfare are at stake."[78] Subtitle C of RCRA outlines the system for controlling hazardous waste from the time it is generated to the time of its disposal.[79] As acknowledged by EPA, but for EPA's irresolute 1991 Bevill

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[71] Sandu, Daljit et. al. 2018. Fate and Transport of Radioactive Gypsum Stack Water Entering the Floridan Aquifer due to a Sinkhole Collapse, SCIENTIFIC REPORTS 8: 11439, https://www.nature.com/articles/s41598-018-29541-0.
[72] FDEP, Industrial Wastewater Facility Permit, Mosaic Fertilizer, LLC – New Wales Concentrates Plant, Number FL0036421 at 4 (Oct. 15, 2021); FDEP Application Phase IV Gypsum Stack Extension, Mosaic New Wales, *supra* note 67, at 80.
[73] FDEP, Wastewater Compliance Inspection Report, Mosaic New Wales (Oct. 21, 2021).
[74] Letter from Vishwas Sathe, FDEP to Santino A. Provenzano, Mosaic Re: Subsurface Activity Early Detection System, Area of Interest 2 (AOI2) & Critical Condition Updates, New Wales Concentrates Plant – Phase II South Phosphogypsum Stack, Wastewater/NPDES Facility ID No. FL0036421 (June 2, 2022).
[75] Steve Newborn, *The troubled Mosaic phosphate mine reports a possible gypstack liner tear*, (Oct. 26, 2023), Troubled Mosaic phosphate mine reports a possible gypstack liner tear | WUSF.
[76] "These conditions are indicative of a breach in the primary HDPE liner on the base of the stack caused by an anomaly in the underlying foundation and constitute a critical condition . . ." Letter from Ardaman & Associates to Mosaic Re: Confirmed Critical Condition at Area of Interest 4, New Wales Plant South Gypsum Stack (SGS), Phase II West-North Area, Mosaic Fertilizer, LLC, New Wales Facility, Polk County, Florida (December 14, 2023).
[77] 42 U.S.C. § 6902(a).
[78] *Telecomms. Research and Action Ctr.*, 750 F. 2d at 80.
[79] 42. U.C.S. § 6921.

determination, phosphogypsum and process wastewater would in most cases be regulated as hazardous waste under RCRA Subtitle C.[80]

1. **Radiation exposure during EPA's delay threatens significant harm to human health and the environment.**

Active phosphogypsum stacks, as currently managed, are entirely uncovered, open-air dumps storing acidic process wastewater together with solid phosphogypsum.[81] This long-existing management strategy facilitates the mobility of several toxic constituents within the wastes that would be abated if the two wastes were managed separately and under Subtitle C.[82]

Radon exposure is the leading cause of lung cancer among non-smokers, and Floridians living in the central Florida phosphate mining region have a two-fold increase in lung cancer risk.[83] Having failed to require separate waste management and adequate regulation, but recognizing the increased risk posed by phosphogypsum exposure nonetheless, in 1989 EPA codified the phosphogypsum stack management strategy into a National Emission Standard for Hazardous Air Pollutants (NESHAP), banning off-site phosphogypsum use to prevent an unacceptable increase in radon exposure and fatal cancer risk should the industry make these even worse by selling its waste to taxpayers for road construction.[84] The industry currently plans to do so now, more than 30 years after EPA first instituted the off-site use ban, despite no demonstrated or quantified reduction of the previously EPA-determined unacceptable risk posed by phosphogypsum-constructed roads, and no change in the scientific understanding of the fatal cancer risk posed by radiation and radon emissions since. [85]

EPA concluded during its NESHAP rulemakings that phosphogypsum stacks, while preventing widespread distribution of radiation exposure through commerce as radioactive road base material or other product, still pose a considerable air-pathway cancer risk.[86] In addition to radon gas emissions, dust emissions in the arid West where J.R. Simplot operates, and even in the Southeast where Nutrien and Mosaic operate and where construction vehicles driving over the stacks remove the crusts, create an inhalation pathway for the toxic constituents within phosphogypsum dust particles.[87] Among these toxic constituents are arsenic, chromium, and

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[80] "Because the available data indicate that process wastewater and phosphogypsum may exhibit the hazardous waste characteristics of EP toxicity and/or corrosivity, these materials would in many cases [subject to hazardous waste determinations if not specifically listed by EPA as RCRA hazardous wastes] be regulated as hazardous waste under RCRA Subtitle C were it not for the [temporary] Mining Waste Exclusion [indefinitely extended by the 1991 Bevill determination for special wastes.]" 1990 Report to Congress at 12-48.
[81] Petition for Rulemaking, *supra* note 3, at 26.
[82] Report to Congress, *supra* note 4, at 7.
[83] Health Risk of Radon, EPA, https://www.epa.gov/radon/health-risk-radon (last visited Mar. 28, 2024); H. G. Stockwell et al., Cancer in Florida: Risks Associated with Residence in the Central Florida Phosphate Mining Region, AMERICAN JOURNAL OF EPIDEMIOLOGY, Volume 128, Issue 1, (July 1988), Pages 78–84.
[84] *National Emission Standards for Hazardous Air Pollutants; Radionuclides*, 45 Fed. Reg 51654, 51675 (Dec. 15, 1989). Upon reconsideration at the request of the industry, EPA amended the NESHAP in 1992 to provide for limited agricultural and research uses. *National Emission Standards for Hazardous Air Pollutants; National Emissions Standards for Radon Emissions from Phosphogypsum Stacks*, 57 Fed. Reg. 23305, 23305 (June 3, 1992).
[85] Requests for Additional Use of Phosphogypsum in Road Construction, *supra* note 23.
[86] 45 Fed. Reg 51654, 51675.
[87] Report to Congress, *supra* note 4, at 12-24

radionuclides, including radium-226.[88] Based on these risks, the EPA concluded that phosphogypsum stacks present a total air pathway lifetime increased risk of fatal cancer to the maximally exposed individual of approximately nine in 100,000.[89] In other words, if 100,000 people were similarly situated to the maximally exposed individual living near a phosphogypsum stack, approximately nine people would die from air pathway exposure to phosphogypsum alone.

A study examining mortality over decades in a cohort of Florida phosphate fertilizer plant workers found significant elevated mortality due to all causes, including cancers like lung cancer and leukemia, as compared to the overall U.S. population and the population of Florida, as well as increased incidence of mental disorders and chronic obstructive pulmonary disease (COPD).[90] Although the authors could not establish an exposure-response relation due to limitations of the study, they noted that phosphate processing results in exposures to aerosolized radiation, acid vapors, and other airborne toxins.[91] Radiation exposure routes to fertilizer plant workers and local residents near fertilizer plants include external radiation, inhalation and ingestion of radionuclide-containing dust, and inhalation of radon and radon daughters.[92]

2. Other toxic constituents threaten significant harm to human health and the environment.

The inhalation of radionuclide-containing particulates and radon gas emitting from phosphogypsum increase the risk of fatal cancer for people living near phosphogypsum stacks.[93] However, phosphogypsum, phosphogypsum leachate, and process wastewater are not only radioactive, they also contain several other toxic constituents that present a hazard to human health and the environment,[94] including arsenic, lead, nickel, cadmium, chromium, silver, antimony, copper, mercury, thallium, selenium, and fluoride.[95] Process wastewater is corrosive, with pH values typically lower than 2 and as extreme as 0.5 (battery acid has a pH of around 1).[96] Process wastewater contaminating groundwater and surface waters also contains toxic constituents, with concentrations of cadmium, chromium, and selenium meeting or exceeding EPA regulatory levels in 1990.[97]

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[88] *Id.*
[89] 45 Fed. Reg 51654, 51675; 57 Fed. Reg. 23305, 23305. The Clean Air Act sets a much lower excess risk goal of one in one million to the maximally exposed individual for hazardous air pollutants and directed the EPA to promulgate NESHAPs with periodic revisions to lower current risks until this goal is achieved. 42 U.S.C. §7412 (f)(2)(A).
[90] James H. Yiin et al., *A Study Update of Mortality in Workers at a Phosphate Fertilizer Production Facility*, 59 AM. J. INDUS. MED. 12, 18 (2017), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4913354/pdf/nihms-794481.pdf.
[91] *Id.*
[92] Kwang Pyo Kim et al., *Characterization of Radioactive Aerosols in Florida Phosphate Processing Facilities*, 40 AEROSOL SCIENCE & TECH. 410 (2006), https://www.tandfonline.com/doi/epdf/10.1080/02786820600643313?needAccess=true
[93] 54 Fed. Reg. 51654, 51675.
[94] Petition for Rulemaking, *supra* note 3, at 19-38.
[95] Report to Congress, *supra* note 4, at 12-8.
[96] *Id*. at 12-58.
[97] The Extraction Procedure test has since been replaced by the more rigorous TCLP test. 40 C.F.R. § 261.24(a).

Several studies have noted an association between chronic exposure to high levels of *arsenic* and lung cancer in occupationally exposed subpopulations.[98] Ingesting arsenic has been reported to increase the risk of cancer in the skin, liver, bladder, and lungs, and the U.S. Department of Health and Human Services has determined that inorganic arsenic is known to be a human carcinogen.[99]

The toxic effects of *lead* exposure include adverse impacts to neurological, renal, cardiovascular, hematological, immunological, reproductive, and developmental systems, especially in children, even at levels of less than 5 µg/d.[100] In fact, the Centers for Disease Control and Prevention states that "no safe blood lead level in children has been identified."[101] The U.S. Department of Health and Human Services classifies lead and lead compounds as reasonably anticipated to be human carcinogens.[102]

Long-term exposure to *cadmium* through air, water, soil, and food leads to cancer and organ system toxicity such as skeletal, urinary, reproductive, cardiovascular, central and peripheral nervous, and respiratory systems.[103] Breathing air with very high levels of cadmium can severely damage the lungs and may cause death.[104] Chronic exposure to low levels of cadmium in the air results in a build-up of cadmium in the kidney and may result in kidney disease.[105] Lung cancer has been found in some studies of workers exposed to cadmium in the air.[106] Chronic ingestion of cadmium can lead to a build-up of cadmium in the kidneys and kidney disease.[107] Chronic exposure to low levels of cadmium can also cause bones to become fragile and break easily.[108] The U.S. Department of Health and Human Services has determined that cadmium and cadmium compounds are known human carcinogens.[109]

The primary effects associated with exposure to *chromium* (VI) compounds are respiratory, gastrointestinal, immunological, hematological, reproductive, and developmental, while the primary effects associated with exposure to chromium (III) compounds are respiratory and immunological.[110] Numerous epidemiological studies recognizing the causal relationship

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98 James Hughes et. al., *Evaluation and Synthesis of Health Effects Studies of Communities Surrounding Arsenic Producing Industries*, 17 INT'L J. EPIDEMIOLOGY 407 (1998), https://pubmed.ncbi.nlm.nih.gov/3042651/.
99 *Id.*
100 *Id*. at 3.
101 *Id.*
102 *Id*. at 5.
103 Mehrdad Rahimzadeh et al., *Cadmium Toxicity and Treatment: An Update*, 8 Caspian J Intern Med. 135–145, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5596182/#:~:text=Long%2Dterm%20exposure%20to%20cadmium,hair%2C%20nail%20and%20saliva%20samples.
104 Agency for Toxic Substances and Disease Registry, Toxicological Profile for Cadmium (2012) at 4, https://www.atsdr.cdc.gov/toxprofiles/tp5.pdf.
105 *Id.*
106 *Id.* at 5.
107 *Id.*
108 *Id.*
109 *Id.*
110 Agency for Toxic Substances and Disease Registry, Toxicological Profile for Chromium (2012), https://www.atsdr.cdc.gov/toxprofiles/tp7.pdf.

between chromium inhalation and lung cancer have been published since the 1940s.[111] The International Agency for Research on Cancer (IARC) has determined that chromium (VI) compounds are carcinogenic to humans.[112]

Exposure to dust containing relatively high levels of *silver* compounds may cause breathing problems, lung and throat irritation and stomach pain,[113] and occupational exposure to airborne *nickel* has caused chronic bronchitis, reduced lung function, and cancer of the lung and nasal sinus.[114]

Electrocardiogram abnormalities were found in about 50% of workers exposed to *antimony* compounds.[115] Other health effects that have been observed in animals orally exposed to higher doses of antimony include hepatocellular vacuolization, hematological alterations including decreases in red blood cell counts and hemoglobin levels, and histological alterations in the thyroid.[116]

Long-term exposure to *copper* dust can irritate the nose, mouth, and eyes, and cause headaches, dizziness, nausea, and diarrhea.[117] Water that contains higher than normal levels of copper may cause vomiting, stomach cramps, or diarrhea. High intakes of copper can cause liver and kidney damage and even death.[118]

The nervous system is highly sensitive to *mercury*.[119] Permanent damage to the brain has been shown to occur from exposure to sufficiently high levels of metallic mercury.[120] The kidneys are also sensitive to the effects of mercury, because mercury accumulates in the kidneys and causes higher exposures to these tissues, and thus more damage.[121] All forms of mercury can cause kidney damage if large enough amounts enter the body.[122]

Thallium can affect the human nervous system, lung, heart, liver, and kidney if large amounts are eaten or drunk for short periods of time.[123] Temporary hair loss, vomiting, and diarrhea can also occur, and death may result after exposure to large amounts of thallium for short periods.[124]

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[111] Peter S.J. Lees, *Chromium and Disease: Review of Epidemiologic Studies with Particular Reference to Etiologic Information Provided by Measures of Exposure*, 92 ENV'T HEALTH PERSP. 93, 93-104, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1519377/pdf/envhper00388-0095.pdf.
[112] Toxicological Profile for Chromium, *supra* note 110, at 4.
[113] *Id.*
[114] *Id.* at 6.
[115] Agency for Toxic Substances and Disease Registry, Toxicological Profile for Antimony and Compounds (2019), https://www.atsdr.cdc.gov/toxprofiles/tp23.pdf.
[116] *Id.*
[117] Agency for Toxic Substances and Disease Registry, Toxicological Profile for Copper (2004) at 6, https://www.atsdr.cdc.gov/ToxProfiles/tp132.pdf.
[118] *Id.*
[119] Agency for Toxic Substances and Disease Registry, Toxicological Profile for Mercury (1999), https://www.atsdr.cdc.gov/toxprofiles/tp46.pdf.
[120] *Id*.
[121] *Id.*
[122] *Id.*
[123] Agency for Toxic Substances and Disease Registry, Toxicological Profile for Thallium (1992), https://www.atsdr.cdc.gov/toxprofiles/tp54.pdf.
[124] *Id.*

Thallium can be fatal from a dose as low as 1 gram.[125] As in humans, animal studies indicate that exposure to large amounts of thallium for brief periods of time can damage the nervous system and heart and can cause death.[126] Animal reproductive organs, especially the testes, are damaged after drinking small amounts of thallium contaminated water for 2 months.[127]

Excess *fluoride* can result in dental fluorosis and in an increased prevalence of bone fractures in the elderly or skeletal fluorosis.[128] Direct contact with fluoride can result in tissue damage.[129] At high concentrations, fluoride can cause irritation and damage to the respiratory tract, stomach, and skin following inhalation, oral, and dermal exposure, respectively. Inhalation of hydrogen fluoride gas at low concentrations causes eye, nose, and skin irritation, and breathing in a large amount can cause lung, heart, kidney damage and death. Hydrofluoric acid burns skin over several hours or days after exposure, causing painful wounds and tissue loss, and in the worst cases, death.[130]

Selenium is a naturally occurring trace mineral and byproduct of sulfuric-acid production, and people exposed to elevated air concentrations of selenium have reported dizziness, fatigue, and irritation of mucous membranes.[131] The EPA has also established drinking water regulations at .05 µg/L for which exposure above this amount can cause numbness and circulatory problems in humans.[132]

The EPA's delay in responding to the 2021 Petition is unreasonable because it frustrates Congressional intent in enacting RCRA and creates a significant risk to human health and welfare hazards to human health and the environment.[133] While EPA refuses to take action, the phosphogypsum and process wastewater burden continues to grow at an unmanageable rate along with the risks. Global annual phosphogypsum production, at a rate of over 5 tons of phosphogypsum per one ton of phosphoric acid produced in a toxic chemical reaction known as the wet process, climbed to approximately 445 million tons of phosphogypsum in 2022, up from approximately 332 million tons in 2009.[134] Domestically, the inadequately regulated industry pushes forward with alarming expansion plans during EPA's unreasonable delay. For example,

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[125] *Id.*
[126] *Id.*
[127] *Id.*
[128] Agency for Toxic Substances and Disease Registry, Toxicological Profile for Fluorides, Hydrogen Fluorine, and Fluorine (2003) at 7–9, https://www.atsdr.cdc.gov/toxprofiles/tp11.pdf.
[129] *Id.*
[130] *Id.*
[131] Agency for Toxic Substances and Disease Registry, Toxicological Profile for Selenium (2003) at 5, https://www.atsdr.cdc.gov/ToxProfiles/tp92.pdf.
[132] 40 C.F.R. § 141.23(a)(4)(i).
[133] National Archives, Resource Conservation and Recovery Act, https://www.federalregister.gov/resource-conservation-and-recovery-act-rcra-.
[134] *Production volume of phosphoric acid worldwide from 2009 to 2021*, STATISTA – INTERNATIONAL FERTILIZER INDUSTRY ASSOCIATION , https://www.statista.com/statistics/1287057/global-phosphoric-acid-production/. Ninety-six percent of phosphoric acid is produced using the phosphogypsum and process wastewater-generating wet process. EPA, Background Report, AP=42, Section 5.11 Phosphoric Acid, https://www.epa.gov/sites/default/files/2020-09/documents/final_background_document_for_phosphoric_acid_section_8.9.pdf.

since the 2021 petition, Mosaic has completed construction activities on a 150-acre expansion[135] at the active, sinkhole-prone New Wales phosphogypsum stack sited upon geologically unstable karst on June 8, 2023,[136] and has recently requested approval for yet another expansion of 289 acres from the FDEP.[137] This would bring the stack to a monstrous 1,539 acres total and further increase exposure risk via emissions, groundwater contamination, sinkholes, and other stack failures and breaches while petitioners await a response from EPA.[138]

C. EPA's delay prejudices environmental justice communities closest to these phosphogypsum stacks.

EPA's continued delay prejudices the interests of Conservation Organizations' members in the health of their communities located near phosphogypsum stacks. Fence-line communities located next to industrial facilities and are directly affected by the operation of those facilities. In general, African Americans are 75% more likely to live in these fence-line communities than the average American.[139] This is not a coincidence, as many companies take advantage of communities with lower levels of political power.[140] Multiple phosphogypsum stacks are located near such communities,[141] and EPA's continued exemption of phosphogypsum and process wastewater from Subtitle C regulations without developing an alternative means of addressing the risks posed by these wastes while continuing to egregiously ignore Conservation Organizations' petition means that these communities have even less protection from toxicity and pollution than they would if they were located near identified and acknowledged hazardous waste disposal facilities.

1. Hurricanes and sea-level rise at phosphogypsum stacks in the Gulf region leave environmental justice communities vulnerable during EPA's delay.

Many of these communities are in the Gulf region where phosphogypsum stacks are prone to dam breaches and susceptible to hurricane damage and some of the highest rates of sea level rise.[142] For example, in 2004, wave action in the process wastewater pond during Hurricane Frances caused a dam to breach at the active phosphogypsum stack at the Riverview fertilizer plant, currently operated by Mosaic in Tampa Bay, FL, causing 65 million gallons of toxic, acidic process wastewater to release into Archie Creek, Hillsborough Bay, and surrounding wetlands. The spill drastically lowered pH, directly killing thousands of fish, crabs, and bottom-dwelling organisms, and damaging 10 acres of seagrass beds and more than 135 acres of wetland habitats, including almost 80 acres of mangroves. This death toll does not even include the subsequent

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[135] FDEP, Industrial Wastewater Facility Permit, Mosaic New Wales, Permit Number FL0036421 (Mar. 15, 2024) at 3.
[136] Ardaman & Associates on behalf of Mosaic,
[137] FDEP Phase IV Gypsum Stack Extension, Mosaic New Wales, *supra* note 67, at 40.
[138] *Id.*
[139] Lesley Fleischman, Clean Air Task Force and Marcus Frankli, *Fumes Across the Fence Line: The Health Impacts of Air Pollution from Oil & Gas Facilities on African American Communities* (Nov. 2017), .https://naacp.org/resources/fumes-across-fence-line-health-impacts-air-pollution-oil-gas-facilities-african-american.
[140] *Id.*
[141] *See, e.g.*, EPA EJ Screen, Mosaic Riverview, Mosaic Uncle Sam, https://ejscreen.epa.gov/mapper/.
[142] Ethan Huang, *Why Seas are Rising Faster on the Southeast Coast*, Sea Level Change, NASA (June 6, 2023), https://sealevel.nasa.gov/news/264/why-seas-are-rising-faster-on-the-southeast-coast/.

harm to fish and other aquatic organisms caused by the influx of nutrients that disrupted the local ecosystem. The other phosphogypsum stack at the Riverview facility,

2. Liner tears, seepage outbreaks, and a large, foul-smelling fire near Progress Village, Florida leave environmental justice communities vulnerable during EPA's delay.

Active phosphogypsum stacks like the Riverview stack continue to expand, and endangerments continue unabated, despite environmental justice concerns and President Biden's recent executive orders committing agencies to environmental justice for all.[143] For example, perhaps because the Piney Point UIC was authorized, Mosaic is now actively applying for at least one other Class I UIC well for process wastewater disposal for its Riverview gypstack.[144] The Mosaic Riverview facility is adjacent to the historically Black environmental justice community of Old Progress Village. Progress Village was designed in the 1950s as a means to provide home ownership to Tampa's segregated Black residents, who lived primarily in housing projects and were purposefully displaced by construction of an interstate.[145] The community fought against the approval of the phosphogypsum stack intended to be located near a school, but Hillsborough County Commissioners ultimately approved the proposal in 1984.[146] The community has been subject to the hazards imposed by the Riverview phosphogypsum stacks for decades.[147] And there is no end in sight as active stack expansion construction activities continue despite concentrated seepage outbreaks in January and August of 2022,[148] continued exceedances of groundwater standards,[149] and multiple recent liner tears, with two of the latest known liner tears occurring in October of 2023, with another as recently as March 4, 2024.[150]

Most recently, a fire at the Riverview stack required 39 units of firefighters to fight and control the blaze.[151] Residents of the area reported seeing thick black smoke beginning on March 25, 2024 with many assuming the fire originated at Mosaic's plant.[152] The fire was extinguished by firefighters, but sparked again on March 26 and early reports of the fire indicate it burned through high density polyethylene pipes at the plant, causing the fire to rapidly spread.[153] FDEP

[143] Revitalizing Our Nation's Commitment to Environmental Justice for All, 88 Fed. Reg. 25251 (Apr. 26, 2023); Tackling the Climate Crisis at Home and Abroad, 86 Fed. Reg. 7619 (Feb. 1, 2021).
[144] Mosaic Fertilizer, LLC, Initial Application to Construct Class I Injection Well System Hillsborough County dated October 17, 2023.
[145] Baum, Laura E. 2016. Neighborhood Perceptions of Proximal Industries in Progress Village, FL, UNIVERSITY OF SOUTH FLORIDA SCHOLAR COMMONS (2016) at 7-8.
[146] *Id*. at 74.
[147] *Id*. at 67.
[148] Occurring after Mosaic implemented a change in operations to accommodate the latest planned lateral expansion. Ardaman & Associates for Mosaic, Application for FDEP Permit Renewal and Supporting Engineering Information, FDEP Permit No FL000761, Riverview Facility, Attachment I, Site Information at 6.
[149] Ardaman & Associates for Mosaic, Application for FDEP Permit Renewal and Supporting Engineering Information, FDEP Permit No FL000761, Riverview Facility, Attachment III, Groundwater Monitoring, at 5-9.
[150] Email from Tina Madrid, Mosaic Fertilizer, LLC to Lance Kautz, FDEP RE: Riverview Critical Condition 10/11/2023 (Oct. 11, 2023 at 4:10 PM EST).
[151] Andrea Chu, '*High Density Plastic Pipes' burn in massive fire at Mosaic fertilizer plant in Hillsborough County*, 10 Tampa Bay (updated Mar. 26, 2024), https://www.wtsp.com/article/news/local/hillsboroughcounty/black-smoke-fire-riverview-hillsborough-mosaic/67-60568bd1-c7f0-4c0e-b3a7-50e9d90015eb.
[152] *Id*.
[153] *Id*.

has stated it would be looking into the incident,[154] and issued a Public Notice of Pollution for an indeterminate quantity of 1,3 Pentadiene.[155] While details of this disaster are forthcoming, this fire demonstrates the threat that these toxic and hazardous stacks pose to their surrounding community without proper oversight. Because the fertilizer industry has demonstrated its nonchalance towards safety and environmental protections, evidenced by the numerous disasters and critical conditions that occur regularly at these stacks, the EPA's delay is unreasonable and furthering the harm to neighboring communities and the environment.

3. Weak soils, structural instability, and lateral phosphogypsum stack movement in St. James Parrish, Louisiana leave environmental justice communities vulnerable during EPA's delay.

Another stack near a predominantly Black environmental justice community, the Mosaic Uncle Sam facility in St. James, Parrish, Louisiana has been moving laterally since 2019, putting surrounding communities and downstream Mississippi River at risk.[156] The EPA determined that Louisiana stacks should be no more than 40 feet tall because of weak soil,[157] but the Uncle Sam stack, under state regulation and not federal hazardous waste regulation, is now nearly 200 feet tall and suffering stability issues as a result.[158] Despite this continued and alarming instability and lateral shifting – evidence of which was first noticed not by EPA, state regulators, or the facility owner-operator, but by a neighboring farmer – the Louisiana Department of Environmental Quality (LDEQ) recently noticed a proposed permit approving Mosaic's request to expand the phosphogypsum stack unacceptably putting this environmental justice community at further risk.[159]

4. The expansion of a Superfund site into public, tribal ceded lands near the Fort Hall Indian Reservation leaves environmental justice communities vulnerable during EPA's delay.

The Blackrock Land Exchange is one of the most egregious examples of the environmental justice issues that go to the heart of phosphogypsum generation. The Shoshone-Bannock Tribes in Idaho have been fighting an uphill battle against the expansion of an ever-growing gypstack threat for decades while the EPA continues to delay action. Under an 1898 treaty, the Tribes retained the rights to hunt, fish, and harvest timber on ceded lands that "remain part of the public

[154] Emily Wunderlich & Max Chesnes, *Firefighter injured during Mosaic fire at Riverview phosphate plant*, TAMPA BAY TIMES (updated Mar. 26, 2024), https://www.tampabay.com/news/hillsborough/2024/03/26/mosaic-phosphate-plant-riverview-brush-fire/.
[155] FDEP, Public Notice of Pollution, Mosaic-Riverview, dated Mar. 26, 2024.
[156] Louisiana DEQ, Uncle Sam Facility, Government Review of Root Cause Analysis (Mar. 2, 2020).
[157] Report to Congress, *supra* note 4, at 12-19.
[158] Tom Wright, *Mosaic says it can keep wastewater on site in case of breach*, THE LENS (Feb.19, 2019), https://thelensnola.org/2019/02/13/mosaic-says-it-can-keep-wastewater-on-site-in-case-of-breach/.
[159] LDEQ, Public Notice LDEQ Mosaic Fertilizer LLC-Uncle Sam Plant Gypsum Management Area and Appurtenances Public Hearing and Request for Public Comment on a Draft Solid Waste Permit Renewal and Associated Environmental Assessment Statement, Permit Number: P-0103-R1-MI2, AI Number: 2532 (Feb. 15, 2024)

domain."[160] In the 1940s, J.R. Simplot's Don Plant started operations next to and within the Fort Hall Indian Reservation, constructing unlined gypstacks and causing decades of groundwater contamination that continues to discharge into the Portneuf River and flow onto the Fort Hall Indian Reservation.[161] After decades of contamination, EPA designated the Don Plant phosphogypsum stack as a Superfund site on the National Priorities List under CERCLA in 1998.[162]

In August 2020, the Department of Interior approved an alternative in the Environmental Impact Statement (EIS) prepared by the Bureau of Land Management (BLM) exchanging 713.67 acres of Federal land for non-federal land owned by Simplot to allow for its expansion onto ceded lands.[163] The Tribes fought against this decision, and in March 2023, the District Court of Idaho ruled that the exchange violated the National Environmental Policy Act and the Federal Land Management and Policy Act, the 1900 Act, and the APA.[164] However, the Court did not decide on the remedy, acknowledging that because the land exchange occurred two years ago, "unwinding the deal is no easy matter."[165] In June 2023, Judge Winmill granted Simplot's Motion to Certify Interlocutory Appeal.[166] The BLM and Simplot appealed the District Court's decision in January 2024, and a decision on appeal is pending.

These environmental injustices are all too common in the management of toxic waste, and the EPA needs to elevate the interests of these communities. Concerning phosphogypsum specifically, the EPA has effectively ignored fence-line communities in decision-making for decades. The EPA needs to respond to the 2021 Petition to acknowledge these interests and address the harms brought by the unreasonable delay.

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[160] *Shoshone-Bannock Tribes of Fort Hall Reservation v. Daniel-Davis*, No. 4:20-CV-00553-BLW, 2023 WL 2744123, at *1 (D. Idaho Mar. 31, 2023), *amended*, No. 4:20-CV-00553-BLW, 2023 WL 5345102 (D. Idaho June 30, 2023).
[161] *Id*.
[162] *Id*. at 2. The phosphogypsum stack at the Don Plant is operating unit (OU 2) within the Easterm Michaud Flats Superfund Site.
[163] *Id.* at 3.
[164] *Id*. at 1.
[165] *Id*. at 6.
[166] *Shoshone-Bannock Tribes of Fort Hall Reservation v. Daniel-Davis*, No. 4:20-CV-00553-BLW, 2023 WL 5345102, at *2 (D. Idaho June 30, 2023).

V. CONCLUSION

For the foregoing reasons, the EPA is in violation of RCRA and the APA for the unreasonable delay in responding to the 2021 Petition. If the requests under RCRA are not answered on or before the 60th day after receiving this notice, Conservation Organizations intend to file a legal action to compel an answer.

Sincerely,

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On behalf of Conservation Organizations

United States
Environmental Protection
Agency

Air And
Radiation
(ANR-459)

402-R92-002
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EPA

Potential Uses Of Phosphogypsum And Associated Risks

Background Information Document

40 CFR 61 Subpart R
National Emission Standards for
Radon Emissions from
Phosphogypsum Stacks

402-R-92-002

POTENTIAL USES OF PHOSPHOGYPSUM AND ASSOCIATED RISKS

BACKGROUND INFORMATION DOCUMENT

for

40 CFR 61 Subpart R
National Emission Standards for
Radon Emissions from
Phosphogypsum Stacks

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PREFACE

The Environmental Protection Agency (EPA) is promulgating revisions to 40 CFR Part 61, Subpart R, National Emission Standards for Radon Emissions From Phosphogypsum Stacks. This Background Information Document (BID) has been prepared in support of the rulemaking. This BID contains an introduction, a general description of the fertilizer industry, a discussion of the physical and radiological characteristics of phosphogypsum, a discussion of the uses of phosphogypsum, analyses of the radiological risks associated with various uses of phosphogypsum, and an analysis of the availability and costs of substitute materials.

Copies of this BID, in whole or in part, are available to all interested persons. For additional information, contact Craig Conklin at (703) 308-8755 or write to:

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1. INTRODUCTION

1.1 FEDERAL REGULATORY BACKGROUND

The off-site use of phosphogypsum was prohibited by the final National Emission Standards for Hazardous Air Pollutants (NESHAPs) for radionuclides promulgated at 40 CFR Part 61, Subpart R, National Emission Standards for Radon Emissions from Phosphogypsum Stacks (54 FR 51654, December 15, 1989). This rule requires that as of the effective date of the rule (March 15, 1990), phosphogypsum be disposed of in stacks or in mines, prohibiting uses of phosphogypsum in construction, agriculture, or research and development.

Because of concerns about the potential impact on farmers, researchers, and other users of phosphogypsum, a Notice of Limited Reconsideration was published in the Federal Register on April 10, 1990 (55 FR 13480). Simultaneously EPA issued a limited class waiver allowing the continued use of phosphogypsum for agricultural application during the 1990 growing season. This waiver had an expiration date of October 1, 1990. However, the waiver was extended on September 28, 1990 with an expiration date of June 1, 1991 (55 FR 40834), and again on May 16, 1991 with an expiration date of October 1, 1991 (56 FR 23519). When the waiver expired on October 1, 1991, all persons holding stacks of phosphogypsum became subject to the work practice requirements in subpart R.

In conjunction with the Notice of Limited Reconsideration, EPA issued a notice of proposed rulemaking at 55 FR 13482 which contains the following options:

1) Retain Subpart R as promulgated on December 15, 1989;

2) Establish a threshold level of radium-226 which would further define the term "phosphogypsum";

3) Allow, upon prior EPA approval, the use of discrete quantities of phosphogypsum for the research and development of processes to remove radium-226 from phosphogypsum, to the extent that such use is at least as protective of public health as is disposal of phosphogypsum in stacks or mines; and/or

4) Allow, upon prior EPA approval, other alternative use(s) of phosphogypsum to the extent that such use(s) is at least as protective of public health as is disposal of phosphogypsum in stacks or mines.

1.2 PURPOSE AND SCOPE OF THE BID

This Background Information Document (BID) provides information relative to the management, disposal and potential uses of phosphogypsum. It also contains an assessment

of the radiological risks associated with agricultural, construction, and research and development applications of phosphogypsum.

The BID contains a detailed description of the Agency's procedures and methods for estimating the radiological risks associated with the potential uses of phosphogypsum. The material is arranged as shown in the following descriptions of the chapters and appendices.

- Chapter 2 - A general description of the phosphoric acid industry, including phosphate rock, fertilizer, and phosphogypsum production rates and the nature and composition of phosphogypsum.
- Chapter 3 - A description of the potential uses of phosphogypsum, including the quantity of material utilized for each use, and the scope of ongoing research activities.
- Chapter 4 - A detailed description of the risk assessment performed and the results obtained.
- Chapter 5 - A discussion of the availability of nonradioactive materials that could compete with phosphogypsum and the costs associated with their use.
- Chapter 6 - References.
- Appendix A - A description of the PATHRAE pathway equations used in the assessments.
- Appendix B - A description of the Ra-226 soil concentration calculations used in the assessments.
- Appendix C - The risk assessment for the ingestion of soil treated with phosphogypsum based on different application rates and exposure periods.

2. GENERAL DESCRIPTION OF THE FERTILIZER INDUSTRY

2.1 FERTILIZER PRODUCTION

Modern agricultural practice uses large amounts of chemical fertilizers to replenish and supplement the nutrients that growing plants take up from the soil. A number of chemical elements are required to support vigorous plant growth. Most soils contain adequate trace amounts of the minor chemicals required, but to maintain the long-term fertility of the soil, quantities of nitrogenous material, phosphates, and compounds of potassium and sulfur must be replaced.

Phosphorus fertilizer requirements can be met by the application of chemicals derived from natural deposits of what is known as phosphate rock. Phosphate rock does not have a definite chemical composition, and the composition varies in different mining areas. The major phosphorus materials in the rock are geologically in the apatite group, which in high grade ores is about seventy percent calcium phosphate and is mixed with a large number of impurities, such as calcium fluoride, chlorides, chromium, rare earths, and radionuclides.

Extensive deposits of phosphate rock are found in Florida, Tennessee, and North Carolina. Workable deposits are also found in Idaho. The phosphate rock is recovered by open pit mining. Phosphate rock is transported to a washing plant where it is separated from accompanying soil, stones, etc. Particles less than 200 mesh size are called slimes and are separated from the ore at the washing plant creating a slurry of up to one third the total mined tonnage. The slurry is discharged to slime ponds. The material larger than 200 mesh size is treated in an amine flotation circuit to remove the silica sand from the ore, dried, and ground into particle sizes of 150 micrometers or less. The calcium phosphate is nearly insoluble in water and, to be useful as fertilizer, must be converted into a soluble form. This is most commonly done by converting the phosphate content of the rock into phosphoric acid. There are wet and dry processes for doing the conversion. United States production facilities utilize a wet process where the prepared material is digested with sulfuric acid to produce the phosphoric acid. Phosphoric acid is water soluble and can be concentrated, as desired, by evaporating water from the mixture. The byproduct remaining after the acid conversion is largely calcium sulfate and has been given the name phosphogypsum. Gypsum is the common tradename for calcium sulfate, a common building material.

The phosphogypsum product appears as the dihydrate or the hemihydrate form (water molecules attached to the calcium sulfate molecule), depending on the specific processing details. This byproduct material, filtered from the phosphoric acid, is transferred as a water slurry to open air storage areas known as stacks. A stack can be created by filling a previously mined area or constructed directly on the land surface.

2.1.1 Phosphate Rock

Phosphate rock, mined in open-pit mines, consists of about one-third quartz sand,

one-third clay minerals, and one-third phosphate particles. After mining, the ore is processed by beneficiation (washing and flotation processes), followed by drying of the marketable rock. The production of phosphate rock in the United States during 1988 was estimated to be 38 million metric tons (MT)[a] (TFI89). Production in the United States peaked in 1980 when 54 million MT were produced (TVA86), and has since declined at a rate of about 3 percent per year (TVA86, TFI89, BOM88). Phosphate rock inventories have also decreased, from 15 to 7.5 million MT in 1985 and 1988, respectively (TFI89).

Phosphate ores mined in the United States contain uranium concentrations ranging from about 7 to 67 pCi/g (20-200 ppm)[b] (SCA91). This is 10 to 100 times higher than the uranium concentration in typical rocks (1 to 2 ppm). Uranium decay products, such as radium-226, exist with the uranium at near secular equilibrium levels. Actual radium-226 concentrations in central Florida phosphate ore range from 18-84 pCi/g, with an average value of 38 pCi/g (Ro87a). Thorium-232 occurs in the ore at much lower concentrations, ranging between 0.1 to 0.6 pCi/g (SCA91).

2.1.2 The Wet Process

In general, the wet process for manufacturing phosphoric acid involves four primary operations: raw material feed preparation, phosphate rock digestion, filtration, and concentration. The phosphate rock is generally dried in direct-fired rotary kilns, ground to a fineness of less than 150 μm for improved reactivity, and digested in a reaction vessel with sulfuric acid to produce the product, phosphoric acid, and the byproduct, phosphogypsum.

Specific wet-acid processes used include the classic Prayon and Nissan-H processes which generate a dihydrate form of phosphogypsum ($CaSO_4 \bullet 2H_2O$), and the Central-Prayon and Nissan-C processes which generate a hemihydrate form of phosphogypsum ($CaSO_4 \bullet \frac{1}{2}H_2O$) (EPA90). The processes that generate the hemihydrate form result in phosphoric acid concentrations of 40 to 50 percent without evaporation, as opposed to the 30 to 35 percent normally produced by the dihydrate processes. It is uncertain which of the above processes are used by each of the phosphoric acid facilities; however, indications are that only two or three facilities use one of the processes which generate the hemihydrate phosphogypsum while the large majority of the facilities use one of the processes which generate the dihydrate phosphogypsum (EPA90). All four processes generate two special wastes: process wastewater and phosphogypsum.

The phosphogypsum is transferred as a slurry to onsite disposal areas referred to as phosphogypsum stacks. These stacks are generally constructed directly on unused or mined-out land with little or no prior preparation of the land surface. The gypsum slurry is pumped

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[a]One metric ton (MT) is approximately 1.1 tons.

[b]1 ppm U-238 = 0.33 pCi/g or 0.67 pCi/g total uranium, U-238 + U-234.

to the top of the stack where it forms a small impoundment, commonly referred to as a gypsum pond. Gypsum is dredged from the pond on top of the stack and used to increase the height of the dike surrounding the pond. The phosphogypsum stacks become an integral part of the overall wet process. Because the process requires large quantities of water, the water impounded on the stack is used as a reservoir that supplies and balances the water needs of the process. Thus, the stack is not only important as a byproduct storage site, but also contributes to the production process.

As of September 1989, the phosphoric acid production industry consisted of 21 active facilities that use the wet-acid production process (EPA90). Two additional facilities, Agrico's Fort Madison, IA and Hahnville, LA facilities, were on standby at that time. The locations of these facilities are shown in Table 2-1. The majority of the 21 facilities are located in the southeast, with 12 in Florida, three in Louisiana, and one in North Carolina. The combined annual production capacity of 19 reporting facilities is over 11 million MT. In 1988, the aggregate production of nearly 8.5 million MT yielded a capacity utilization rate of about 77 percent (EPA90). Several facilities, however, operated at low utilization rates, e.g., three facilities reported rates of 15.8, 30.1, and 37.5 percent. The generation of 8.5 million MT of P_2O_5[c] would produce an estimated 38 million MT of phosphogypsum, based on 4.5 MT of phosphogypsum per MT P_2O_5 (Gu75).

In 1985, 51 million MT of marketable phosphate rock were produced, of which 41 million MT (80 percent) were used to produce 12 million MT of P_2O_5 by the wet acid process (EPA89a). By 1988, these production figures had dropped to 38 million MT of marketable phosphate rock producing 8.5 million MT of P_2O_5. The main cause for this reduced production, nearly 30 percent, was the poor financial condition of the fertilizer industry during much of the 1980s. These conditions were the result of low domestic demand and reduced foreign purchases (EPA90). About 95 percent of the commercial phosphoric acid produced by the wet process is used in the production of fertilizers and animal feed, with a small portion used as a feedstock in chemical processing operations (BOM87). The data shown in Table 2.2 reflect the use of phosphate fertilizers on major crops, such as coarse grain, wheat, soybeans, and cotton and, as can be seen, the demand for fertilizer closely parallels the acreage of major agricultural crop production. However, the domestic demand for phosphoric acid is expected to increase as a result of the 1988 recovery of the farm economy, and should continue to grow as crop prices and planted acreage increases (EPA90). Non-fertilizer uses of phosphoric acid also declined during the 1980s, due to strict regulations governing the use of phosphates in household products, such as detergents, and a decline in industrial demand (SP88).

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[c]By convention, the phosphate industry relates the production of phosphoric acid to P_2O_5 rather than H_3PO_4.

Table 2-1. Wet process phosphoric acid plants (EPA90).

Operator	Location	Parent Company
Agrico	Donaldsonville,LA	Freeport-McMoRan
Agrico	Mulberry (Pierce), FL	Freeport-McMoRan
Agrico	Uncle Sam, LA	Freeport-McMoRan
Arcadian	Geismar, LA	Arcadian
Central Phos.	Plant City, FL	CF Industries
CF Chemicals	Bartow (Bonnie), FL	CF Industries
Chevron Chemical	Rock Springs, WY	Chevron Corp.
Conserv	Nichols, FL	Conserv
Farmland, Inc.	Bartow (Pierce), FL	Farmland Ind.
Fort Mead Chemical	Fort Meade, FL	US Agric Chem/WR Grace
Gardinier	Riverview (Tampa), FL	Gardinier
IMC Fertilizer	New Wales (Mulberry), FL	IMC Fertilizer
Mobil Mining	Pasadena, TX	Mobil Corp.
Nu-South Ind.	Pascagoula, MS	Nu-West Industries
Nu-West	Soda Springs, ID	Nu-West Industries
Occidental Chem.	White Springs, FL	Occidental Petroleum
Royster	Mulberry, FL	Cedar Holding Co.
Royster	Palmetto (Piney Pt), FL	Cedar Holding Co.
Seminole Fert.	Bartow, FL	Seminole Fertilizer
J.R. Simplot	Pocatello, ID	J.R. Simplot
Texasgulf	Aurora, NC	Texasgulf
Argico[a]	Ft. Madison, IA	Freeport - McMoRan
Agrico[a]	Hahnville, LA	Freeport - McMoRan

[a] On standby in 1989.

Table 2-2. Trends in phosphate fertilizer demand and application (BOM88).

-- Year -- Actual/Projected	Fertilizer Demand (million MT)	Major Crop[a] Harvested Areas (million acres)	Application Rates (Kg/acres)
1980	5.5	331	16.6
1981	5.6	351	15.8
1982	5.0	336	15.0
1983	4.4	297	15.0
1984	5.2	324	16.2
1985	4.9	331	15.0
1986	4.5	311	14.2
1987	4.2	289	14.2
1988	4.2	296	14.2
1990	4.4	309	14.2
1995	5.0	333	15.0
Average[b]	4.8	319	15.0

(a) Major crops include coarse grain, wheat, soybeans, and cotton.

(b) Does not include 1990 or 1995 projections.

2.2 PHOSPHOGYPSUM

2.2.1 Composition of Phosphogypsum

Phosphogypsum, which has an average particle diameter of less than 0.2 mm, is primarily calcium sulfate dihydrate, $CaSO_4 \bullet 2H_2O$, in association with varying amounts of silicon, phosphate and fluoride. Phosphogypsum is only slightly soluble in water, about 2g per liter (EPA89a). Phosphogypsum contains appreciable quantities of radium-226, uranium, and other uranium decay products. This is due to the high uranium concentration in phosphate rock which was discussed in Section 2.1.1. The radionuclides of significance are: uranium-238, uranium-234, thorium-230, radium-226, radon-222, lead-210, and polonium-210. When the phosphate rock is processed through the wet process, there is a selective separation and concentration of radionuclides. Most of the radium-226, about 80 percent, follows the phosphogypsum, while about 86 percent of the uranium and 70 percent of the thorium are found in the phosphoric acid (Gu75).

Table 2-3 shows the average radionuclide concentrations measured in 50 phosphogypsum samples collected in 1985 by EPA from five stacks in central Florida (Ho88). For comparison, the radionuclide concentrations normally observed in uncontaminated rock and soil are also presented. The concentrations measured in the phosphogypsum samples are similar to those previously reported (Gu75) and exceed those in background soil by factors of 10 (uranium) to 60 (radium-226). These radionuclides and radon-222 are possible sources of airborne radioactivity. Radon-222, a decay product of radium-226, is a gaseous element which may diffuse into the air. Also, these radionuclides in particulate form may be resuspended into the air by wind and vehicular traffic. Wind and vehicular traffic are the two principal mechanisms for airborne releases of radioactivity from phosphogypsum stacks.

Table 2-3. Average radionuclide concentrations in phosphogypsum, pCi/g dry weight (Ho88).

Material	Ra-226	U-234	U-238	Th-230	Po-210	Pb-210
Phosphogypsum	31	3.3	3.2	5.1	27	36
Background Soil	0.5	0.3	0.3	0.3	0.5	0.7

The radium-226 concentration in phosphogypsum varies significantly at different sampling locations on a single stack and also in phosphogypsum from different stacks within the same geographical area. This variation is illustrated by the data in Table 2-4. All stacks were active except Estech, which was inactive (closed). The ranges of radium-226 concentrations measured in phosphogypsum collected from stacks in six states are presented

Table 2-4. Radium-226 concentrations in Florida phosphogypsum samples (Ho88).

Phosphogypsum Stack	Mean Concentration (pCi/g dry)[a]	Concentration Range (pCi/g dry)
Gardinier	33±2	31-37
W.R. Grace	30±9	19-48
Royster	30±11	16-49
Conserv	34±18	23-81
Estech	25±4	19-31

(a). Mean concentration with the standard deviation of samples from 10 locations on each stack.

Table 2-5. Radium-226 concentrations in phosphogypsum, listed by state (EPA90).

State	Phosphogypsum Generated in 1988 (MT)	Ra-226 Concentration in Phosphogypsum (pCi/g)
Florida	29,777,000	5.9-36
Idaho	2,646,000	7.9-23
Louisiana	7,280,000	1.4-26
Mississippi	474,000	5.9-36
North Carolina	5,425,000	4.3-46
Texas	1,157,000	13-15

in Table 2-5. The radium-226 concentrations observed in phosphogypsum from Louisiana and Mississippi are similar to those observed in Florida, as might be expected since Florida phosphate rock is processed in those states.

The average activity ratios of the major radionuclides in the composite phosphogypsum samples from the central Florida study are shown in Table 2-6. For example, the activity ratio of Ra-226/U-238 is the average radium-226 concentration in phosphogypsum divided by the average uranium-238 concentration in phosphogypsum. These activity ratios indicate that concentrations of uranium and thorium isotopes are depleted in phosphogypsum relative to their concentrations in phosphate rock. However, the concentration of Ra-226 in phosphogypsum is similar to that in phosphate rock. Thus, most of the radium-226 follows the phosphogypsum in the wet process, while most of the uranium and thorium are in the phosphoric acid product.

In addition to radionuclides, phosphogypsum contains some trace metals in concentrations which the EPA believes may pose a potential hazard to human health and the environment (EPA90). Two contaminants, chromium and arsenic, were identified in phosphogypsum from some facilities at concentrations that may pose significant health risks. The concentrations of these contaminants vary greatly in phosphogypsum from different facilities, ranging over three orders of magnitude. Trace metals may also be leached from phosphogypsum, as are radionuclides, and migrate to nearby surface and groundwater resources. The EPA has identified a number of potential constituents in phosphogypsum from some facilities that could, under the appropriate conditions, cause adverse health effects or the restriction of potential uses of nearby surface or groundwater resources. Elements identified include arsenic, lead, cadmium, chromium, fluoride, zinc, antimony, and copper (EPA90). The presence of these trace metals in phosphogypsum is mentioned here in order to provide a more complete description of phosphogypsum, but they will not be addressed in the risk assessment.

2.2.2 Phosphogypsum Stacks

A total of 63 phosphogypsum stacks were identified nationwide in 1989 (EPA89a). Table 2-7 gives the location, size, and status, as of 1989, for each stack. Phosphogypsum stacks were present in 12 different states, with two-thirds located in just four states, Florida, Texas, Illinois and Louisiana. Of the stacks identified, 26 were operating, 24 were inactive, and 13 were considered idle. An operating or active stack is one that is currently receiving gypsum, and an inactive stack is one that is permanently closed. A stack was classified as idle if there were definite plans to reactivate it and it has the characteristics of an active stack, e.g., water may be maintained on the stack top surface and utilized in the water balance for the facility. The phosphogypsum stacks ranged in area from approximately 5 to almost 741 acres, and heights of the stacks ranged from 3 to about 60 meters.

The number of phosphogypsum stacks in each state is given in Table 2-8. The information in this table relates the phosphogypsum stacks to individual states and gives the

Table 2-6. Average activity ratios of major radionuclides in composite phosphogypsum samples (Ho88).

Radionuclides	Activity Ratio
Ra-226 / U-238	9.1
Th-230 / U-238	1.7
Pb-210 / U-238	13.0
Pb-210 / Ra-226	1.4
Po-210 / Pb-210	0.74
U-234 / U-238	1.1

distribution of stack and stack areas within each category (operating, idle, and inactive). Over half of the operating stacks are in Florida, which accounts for 57 percent of the total base area of all operating stacks. In 1989, the total base area of all phosphogypsum stacks in the United States was approximately 8,490 acres, of which 69 percent was associated with operating stacks, 14 percent with idle stacks, and 17 percent with inactive stacks. From Table 2-8, it is apparent that older inactive stacks are generally much smaller than the newer operating stacks. For example, the average base area of an operating stack was 224 acres, while the average base area of an inactive stack was only 60 acres.

In addition to their large sizes, operating phosphogypsum stacks are characterized by other physical features. Large areas of the stack top are covered by ponds of water, ditches, or beaches (saturated land masses that protrude into the ponds). These surface features may cover up to 75 percent of the top of the stack. Other surface features include areas of loose, dry materials, access roads, and thinly-crusted stack sides. Inactive stacks are characterized by a hard, thick-crusted top and dry, thinly-crusted sides.

2.2.3 Production Rate of Phosphogypsum

The production of phosphogypsum can be estimated by applying the rule of thumb of 4.5 MT of phosphogypsum per Mt of P_2O_5 (Gu75). For illustrative purposes, the annual phosphate rock, phosphoric acid, and phosphogypsum production rates are provided in Table 2-9 for selected years since 1965 (TFI89, TVA86).

Table 2-7. The location and characteristics of phosphogypsum stacks in the United States (EPA89a).

Facility Name		Location	Stack Status	Stack Height(m)	Base Area(acres)
Districhem Inc.[a]		Helena, AR	Inactive	23[a]	22
Agrico Fertilizer Co.		Bartow, FL	Operating	21	346[a]
Royster Phosphate,Inc[a]		Palmetto, FL	Operating	21	299
Brewster Phosphates		Bradley, FL	Inactive	9	124
CF Industries, Inc.		Plant City, FL	Operating	28	400
CF Industries, Inc.		Bartow, FL	Idle[a]	40	361
Conserv, Inc.	1[b]	Nichols, FL	Operating	10	79
	2		Operating	27	77
Estech, Inc.		Bartow, FL	Inactive	9	27[a]
Farmland Industries,Inc.		Bartow, FL	Operating	20	227
Gardinier, Inc.		Tampa, FL	Operating	54	341
Seminole Fertilizer	1	Bartow, FL	Operating	6	158
Corp.	2		Operating	27	561
IMC Corp.		Mulberry, FL	Operating	24[c]	388[c]
Occidental Chem.Co.	1	White Spgs, FL	Operating	22	99
(Suwanne River)	2		Operating	20	99
Occidental Chemical Co. (Swift Creek)		White Spgs, FL	Operating	18	131
Royster Co.	1	Mulberry, FL	Operating	18	74
	2		Operating	24	44
USS Agri-Chemicals,Inc.		Bartow, FL	Inactive	18	49
USS Agri-Chemicals,Inc.		Ft. Meade, FL	Operating	23	151
Nu-West Ind.,Inc.[a]		Conda, ID	Operating	24	89
J.R. Simplot Co.	1	Pocatello, ID	Idle	12[d]	42[d]
	2		Operating	20[d]	200
Bunker Hill Co. 1		Kellogg, ID	Inactive	8[e]	5[e]
	2		Inactive	8[e]	12[e]
	3		Inactive	8[e]	49[e]
General Chemical Corp.		E.St.Louis, IL	Inactive	9	21

Table 2-7. The location and characteristics of phosphogypsum stacks in the United States (EPA89a) (continued).

Facility Name		Location	Stack Status	Stack Height(m)	Base Area(acres)
F&W Flying Service, Inc.		Marseilles, IL	Inactive	6	65
Mobil Mining & Minerals Co.		Depue, IL	Inactive	13	135
Northern Petrochem. Co.		Morris, IL	Inactive	4	69
Olin Corp.	1	Joliet, IL	Idle[a]	27	210[a]
	2		Inactive	5	20[a]
Smith Douglas/Borden		Streator, IL	Inactive	18	25[a]
Quantum Chemical Corp.		Tuscola, IL	Inactive	16	79
Agrico Fert. Co.	1	Ft. Madison,IA	Inactive	30	49
	2		Inactive	9	49
	3		Inactive	5	59
Agrico Fertilizer Co.		Donaldsonville, LA	Operating	12	502[f]
Arcadian Corp.	1	Geismar, LA	Idle	20[a]	94[a]
	2		Idle	12[a]	35[a]
	3		Idle	12[a]	27[a]
	4		Operating	6[a]	22[a]
Agrico Fert. Co.[a]		Hahnville, LA	Operating	4	22
Agrico Fert. Co.[a]		Uncle Sam, LA	Operating	20	702[g]
Nu-South Ind., Inc.[a]		Pascagoula, MS	Operating	20	250
Farmers Chemical Co.		Joplin, MO	Inactive	15	69
W.R. Grace and Co.	1	Joplin, MO	Inactive	10[a]	25
	2		Inactive	10[a]	25
Texasgulf Chem. Co.	1	Aurora, NC	Idle[a]	26[a]	40[a]
	2		Idle[a]	18[a]	74[a]
	3		Idle[a]	38[a]	126[a]
	4		Idle[a]	19[a]	126[a]
	5		Operating[a]	20[a]	126[a]
Amoco Oil Co.	1	Texas City, TX	Idle	11	35
	2		Idle	3	5

Table 2-7. The location and characteristics of phosphogypsum stacks in the United States (EPA89a) (continued).

Facility Name		Location	Stack Status	Stack Height(m)	Base Area(acres)
Kerley Agricultural Chem. of TX Inc.		Pasadena, TX	Inactive	11	27
Mobil Mining and	1	Pasadena, TX	Inactive	27	59
Minerals Div.	2		Inactive[a]	27	89
	3		Operating	30	151
Phillips Chemical Co.		Pasadena, TX	Idle	27	35
Four Court Incorporated		Magna, UT	Inactive[h]	5	299
Chevron Chemical Co.		Rock Sp., WY	Operating	10[i]	450

(a) Jo88b.

(b) Numbers 1,2,3, etc. refer to different stacks at a facility.

(c) Ba88; (d) Si88; (e) Ap88; (f) Wa88b; (g) Wa88a; (h) Co88; (i) Default value.

Note: Information in this table is from PEI85, except for that identified by footnotes (a), and (c) to (i), and relates to 1988-1989 conditions.

These production figures reflect the capacity of the phosphate mining industry for the last 20 years. It is evident from Table 2-9 that the yearly phosphogypsum production has averaged nearly 40 million MT since 1984. However, this estimate may be low, as the estimated quantity of phosphogypsum produced in 1988, 41.9 million MT, is less than the total reported by the EPA for the same year for six of the larger production states, 46.8 million MT (see Table 2-5). The total phosphate waste volume generated in the U.S. from 1910 to 1981 has been estimated at 7.7 billion MT (EPA85). In Central Florida, the phosphoric acid industry produces about 32 million MT of phosphogypsum each year, with a current stockpile of nearly 400 million MT (SCA91).

The amount of phosphogypsum that will be produced in future years is uncertain. Predictions of the amount of phosphogypsum that will be produced during the next 20 years are reported to range from 310 to 910 million MT (SCA91). Thus, although the amount of phosphogypsum that must be managed in future years will certainly be large, it is not possible to predict with a reasonable degree of certainty the growth of the total phosphogypsum inventory in the U.S.

Table 2-8. Summary of the phosphogypsum stacks in each state-1989 (EPA89a).

State	Number of Stacks	Total Base Areas, acres[a]		
		Operating	Idle	Inactive
Arkansas	1	0	0	22 (1)
Florida	20	3319 (16)	361 (1)	200 (3)
Idaho	6	289 (2)	42 (1)	67 (3)
Illinois	8	0	210 (1)	410 (7)
Iowa	3	0	0	158 (3)
Louisiana	7	1248 (4)	156 (3)	0
Mississippi	1	250 (1)	0	0
Missouri	3	0	0	119 (3)
N. Carolina	5	126 (1)	366 (4)	0
Texas	7	151 (1)	74 (3)	175 (3)
Utah	1	0	0	299 (1)
Wyoming	1	450 (1)	0	0
Total	63	5833 (26)	1209 (13)	1450 (24)
Average Stack Area		224	93	60

(a) Number of stacks is shown in parentheses.

Table 2-9. Annual phosphate fertilizer production rates.

Year	Phosphate Rock (million MT)	Phosphoric Acid (million MT)	Phosphogypsum (million MT)
1965	26.8	3.5	15.8
1970	35.1	5.2	23.4
1975	44.3	7.0	31.5
1980	54.4	9.8	44.1
1984	49.2	9.9	44.6
1985	44.8	8.9	40.1
1986	32.8	7.4	33.3
1987	35.7	8.1	36.5
1988	38.3	9.3	41.9

3. USES OF PHOSPHOGYPSUM

3.1 INTRODUCTION

Phosphogypsum is currently being used in several commercial applications with additional research being conducted, primarily by the Florida Institute of Phosphate Research (FIPR), in order to identify new applications and expand existing ones. Currently, applications include (SCA91):

1) fertilizer and conditioner for soils where peanuts and a variety of other crops are grown;

2) backfill and road-base material in roadway and parking lot construction;

3) additive to concrete and concrete blocks;

4) mine reclamation; and

5) recovery of sulfur.

Each application is discussed below. Agriculture, and to a lesser extent mine reclamation, presently utilizes the largest quantities of phosphogypsum. Other uses have not moved past the development stage of field testing in the U.S. However, this could change in the future if present restrictions on the disposal of phosphogypsum are removed. Research is continuing on additional uses of phosphogypsum as a soil conditioner, as well as other uses, e.g., sulfur recovery, in ceramic products, as anti-skid aggregate, and as a concrete aggregate (SCA91).

Due to the absence of low-cost natural gypsum and the lack of long-term storage space, the use of phosphogypsum in Europe and Japan has been much more widespread than in the U.S. These countries have used phosphogypsum extensively in cement, wallboard, and other building materials (SCA91).

Because of the elevated levels of radionuclides, primarily radium-226, in phosphogypsum, building construction materials containing phosphogypsum could result in elevated radiation exposures to building occupants. Phosphogypsum was used by a New Jersey based company in the manufacture of wallboard, partition blocks, and plaster for distribution in the northeastern United States between 1935 and 1946 (Fi78). No wallboard containing phosphogypsum is currently manufactured for commercial use in the United States. Therefore, the use of phosphogypsum in wallboard and the associated risk will not be addressed in this assessment.

Radon measurements conducted in a room constructed of Japanese phosphogypsum wallboard at EPA's National Air and Radiation Environmental Laboratory did not detect any

increase in indoor radon concentrations (Se88). The emanation fraction was estimated to be less than 2 percent. However, a modular structure constructed of ferrocement panels containing 50 percent phosphogypsum, 25 percent cement, and 25 percent fine aggregate resulted in radon levels, measured under worst-case ventilation conditions (i.e., the structure was made as air-tight as possible) that averaged 4 to 5 pCi/L (Ch87). The upper end of this range is above the level at which the EPA recommends that homeowners take action to determine the long-term average radon concentration in their home (EPA86).

The amount of phosphogypsum currently being used in the U.S. for the above purposes is small compared to the total amount being produced. It has been estimated that only about 5 percent of the U.S. phosphogypsum output is utilized in some way (An88). The quantities of phosphogypsum sold each year are compared in Table 3-1 to the annual production rates at eight facilities (Va89). The phosphogypsum sold at these facilities was primarily for agriculture. Although this survey does not include all facilities, it does indicate the small scale use of phosphogypsum in the United States.

3.2 AGRICULTURAL APPLICATIONS

For more than 30 years, phosphogypsum has been used in the United States as a conditioner for clayey and sodic[a] soils because of its moisture retaining and salt leaching properties. Its use is considered critical to maintaining soil productivity in the southeastern states where highly weathered soils have poor physical properties and high erodability (TFI90a). In addition, phosphogypsum provides needed nutrients, such as calcium and sulfur, to deficient soils. The phosphogypsum in the southeast is used primarily by peanut growers in Georgia, North Carolina, Virginia, and Alabama. Studies have also indicated that phosphogypsum may be beneficial to southeastern soils used to grow tobacco, corn, small grain, and sugar cane. Currently, the state of Georgia is the largest consumer of phosphogypsum, applying 120,000 to 180,000 MT annually to its peanut fields. Application rates vary depending on the crop, soil type, and purpose of the amendment. Phosphogypsum is a source of calcium for peanuts and is added at rates of 0.2-0.4 MT/acre per year. It is applied at higher rates, 0.8-1.2 MT/acre per year, on acidic, crusting soils to improve physical properties and mitigate subsoil acidity (Mi91).

There is also a large demand (estimated 500,000 to 750,000 MT/yr (TFI90a, Va89) for agricultural use of gypsum in California to amend sodic soils growing such crops as citrus, almonds, vegetables, and tomatoes. In 1985, more than 270,000 MT of phosphogypsum were applied to fields in California. The sales of phosphogypsum for agriculture declined sharply to about 84,500 MT in 1988, due primarily to the depletion of phosphogypsum stacks in that state. As a result, phosphogypsum is currently being shipped into California from Utah.

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[a]Soils containing elevated levels of sodium.

Table 3-1. Quantities of phosphogypsum sold at eight facilities-1988 (Va89).

Facility Name	Location	Tons Sold Per Year	Percent of Annual Facility Production
Arcadian Corp.	Geismer, LA	5,000	0.7
Farmland Industries, Inc.	Bartow, FL	0-5,000	0 - <0.2
Four Court, Inc.	Magna, UT	200,000[a]	[b]
Mobil Mining & Minerals Div.	Pasadena, TX	[c]	10 - 15
Occidental Chemical Co.	White Springs, FL	100,000	< 1
Royster Co.	Mulberry, FL	[c]	< 1
J.R. Simplot Co.	Pocatello, ID	40,000-50,000	3-4
Texasgulf Chemicals Co.	Aurora, NC	100,000-150,000	2-3

[a] Shipped to San Joaquin Valley, CA.
[b] Facility is inactive, but has about 8 million tons stockpiled.
[c] Information not provided.

The Fertilizer Institute (TFI) circulated a questionnaire to which eight farmers in California and 30 farmers in Georgia who regularly apply phosphogypsum to their fields responded (TFI90a, Appendix 38). The crops grown in the amended soils in California were almonds and walnuts (69 acres), peaches (40 acres), grapes (20 acres), alfalfa, corn, beans, and oats (1080 acres), and trees (75 acres). The farms in Georgia were used exclusively for growing peanuts, a total of about 4,200 acres. The following results were obtained from this survey.

	Georgia	California
Application, tons/acre	0.06 - 1.0 (0.44)[a]	1.0-2.0 (1.3)
Acres Amended per Farm	5-700 (139)	7-1,000 (183)
Years of Application	3-40 (17.3)	2-15 (10.5)
Average Tillage Depth, inches	1-15 (8.3)	0-18 (7.4)[b]

(a) Average values are given in parenthesis.
(b) Depended significantly on crop.

This is a small sampling of the total farmers that apply phosphogypsum to their fields; however, it probably presents a representative cross-section of this practice, particularly for the peanut farmers in the southeastern United States.

3.3 ROAD CONSTRUCTION

Phosphogypsum, mixed with fly ash, sand, gravel, or cement, has been successfully used in the United States as a base for roads, parking lots, and storage areas. The use of phosphogypsum for road bed construction has been most extensive in the Houston, Texas area (L185, Kr88), with some application in Florida (FIPR88). The quantities of phosphogypsum sold for roadbed construction in Texas and Florida in 1988 was estimated to be about 140,000 MT per year (Kr88). The quantities of phosphogypsum used in North Carolina are not available. However, considering the large amount of phosphogypsum in Florida and the strong demand for aggregate in that state, the use of phosphogypsum in road construction could significantly increase. Some applications of phosphogypsum in roadway and parking lot construction are described below (EPA90, TFI90a).

1) Phosphogypsum from Mobil's facility in Pasadena, Texas was mixed with fly ash or cement and used as road base on five sections of city streets in La Porte, Texas, near Houston.

2) In Polk County, Florida, 2.4 km of road base was constructed of a compacted mixture of phosphogypsum and granular sand, and surfaced with one to two inches of asphalt.

3) In Columbia County, Florida, a 2-mile stretch of road base was constructed using both 100 percent dihydrated phosphogypsum and mixtures of phosphogypsum and sand in ratios of 1:2, 1:1 and 2:1. The road base was then surfaced with one to two inches of asphalt.

4) Phosphogypsum has been used commercially in North Carolina as a fill and sub-base in roads crossing swampy areas.

5) A mixture of phosphogypsum (13 percent) and concrete was used to pave 1,670 m^2 (2,000 yd^2) of driveways and parking areas at the Florida Institute of Phosphate Research in Bartow, Florida.

Several investigators have studied direct radiation exposures from gamma-rays and radon-222 resulting from the use of phosphogypsum in roadbed construction. Roessler reports external gamma-ray exposures ranging as high as 20 μR/hr over a roadbed constructed on a 100 percent phosphogypsum base, to 10-11 μR/hr over roadways constructed of a 25 percent phosphogypsum/gravel or sand base and paved with asphalt (Ro87b). Radon flux measurements over the roadways generally ranged between 1 to 2 pCi/m^2-s. When the roadbed was sealed with asphalt, the radon flux was less than 1 pCi/m^2-s. Exposures along the sides of the roadways were near the background gamma-ray and flux levels of 8-10 μR/hr and less than 0.1 pCi/m^2-s, respectively. Another source cites similar exposure levels (An88).

3.4 CONCRETE AND CEMENT BLOCKS

Phosphogypsum has been used on a very limited basis in the manufacture of building materials, e.g., concrete and cement blocks. Phosphogypsum is not currently being used in the United States in the manufacture of building materials. It is widely used for this purpose in Europe and Japan. It is believed that the utilization of phosphogypsum as a raw material for building materials will require further evaluation and probably the establishment of standards for final construction materials. The potential demand for phosphogypsum for this purpose is not known, but would probably not be great. An exception may be in Florida where there are large quantities of phosphogypsum and a high demand for cement. Currently, natural gypsum is used extensively in cement; about 19 percent of the natural gypsum used in the United States is used as an additive to cement (EPA90).

3.5 SULFUR RECOVERY

Extensive research has been conducted to develop a technology to recover sulfur from phosphogypsum. The development stage appears to be complete and the process could become commercially available should the price of sulfur, currently at $110.00/long ton, increase significantly (L191). In general, sulfate is converted to sulfur dioxide (SO_2) by a high temperature decomposition of calcium sulfate ($CaSO_4$) in the phosphogypsum. The sulfur dioxide is scrubbed from the gaseous emissions and sent to the facility's chemical plant where it is converted to sulfuric acid (H_2SO_4) which is utilized in the wet-acid process.

A pilot project to produce sulfuric acid and aggregate has operated successfully at the Agrico plant near Uncle Sam, LA (L191). Using the circular grate process, the plant utilized about 35 tons of phosphogypsum and other materials to produce about 30 tons of sulfuric acid and 25 tons of aggregate per day. The plant began operation in 1988 but is presently mothballed, a result of the low price of sulfur.

Consolidated Minerals, Inc. proposes to construct on a 17,100 acre site in DeSoto County, Florida, a multi-production facility that will include a sulfur recovery process. The sulfur dioxide recovered will be converted to sulfuric acid and used in the phosphate fertilizer production unit to precipitate calcium sulfate. In addition to the usual phosphate fertilizer products, the process will also produce calcium oxide for use in Portland cement. The waste products from the plant will include a more pure phosphogypsum (dihydrate with some hemihydrate and anhydrate forms) containing lower radium-226 concentrations (reported to be less than 5 pCi/g) and the insoluble impurities that contain most of the radium-226. It is planned to return the latter to the mine site as part of the reclamation process. The plant is presently scheduled to begin operation in late 1994.

3.6 MINE RECLAMATION

An alternative to the disposal of phosphogypsum directly in stacks has been developed in which the phosphogypsum is mixed with a phosphatic clay suspension (a waste from the beneficiation of phosphate rock) in the approximate ratio of 3 parts phosphogypsum to 1 part clay. The suspension is then pumped to the disposal site. The mixture will dewater and become consolidated in about one year, after which the surface can be revegetated with grass and trees.

There are two factors that must be considered in determining if a phosphogypsum facility can utilize this disposal method. First, the facility must be located near the disposal site (mine) to keep transportation costs to a minimum. Second, the phosphatic clay suspension must contain sufficient base (e.g. calcium carbonate) to neutralize the acids remaining in the phosphogypsum.

Currently, only Texasgulf's facility near Aurora, North Carolina is using this disposal process. At this facility, phosphogypsum is disposed in a mine adjacent to the plant at about the same rate as it is produced (EPA90). Facilities in Florida and Idaho are close enough to mines to make this disposal process feasible. In 1988, mine reclamation could have utilized more than 32 million MT. However, this use is not viable for facilities in Louisiana, Mississippi, and Texas because their phosphate rock is shipped from Florida, nor at the facility in Rock Springs, Wyoming that receives phosphate rock mined in Utah. In 1988, the combined total phosphogypsum generated at these facilities was nearly 10 million MT (EPA90).

Mine reclamation as a means of phosphogypsum disposal is a viable option that may become more prevalent in the future. Two distinct advantages of mine reclamation over the current practice of placing the material in large stacks are the aesthetic advantage of revegetating the mined-out area, and the greatly reduced potential for the waste to be released to surface water by erosion and to the atmosphere by the wind.

3.7 RESEARCH ACTIVITIES

Extensive research is being conducted under the sponsorship of the Florida Institute of Phosphate Research (FIPR) and other organizations to develop commercial uses for phosphogypsum (FIPR87, FIPR89a, FIPR89b, FIPR90a, FIPR90b). Some current and potential uses for phosphogypsum were listed in Section 3.1 and briefly discussed in Sections 3.2 to 3.6. Research and development projects were being actively pursued in all of these applications until the prohibition on its use was enacted on December 15, 1989 (54 FR 51654).

Numerous research efforts have been directed at expanding and developing beneficial uses for phosphogypsum. The major goals of FIPR, an agency of the State of Florida supported financially by the state severance tax on phosphate, are the prevention of further accumulation of phosphogypsum and the reduction of current inventories. FIPR is engaged in research directed toward the recovery of sulfur and other valuable by-products from phosphogypsum; the possible production of building materials such as aggregate, lime, and cement; the use of phosphogypsum as a road-base material; and its use as an agricultural amendment to enhance calcium and sulfur values in the soil.

FIPR and the phosphate industry are not alone in conducting research on possible uses for phosphogypsum. Louisiana State University has established an Institute for Recyclable Materials, one objective of which is the study of beneficial uses of phosphogypsum. Other southeastern universities, including the University of Florida, the University of Miami, and the University of Georgia are also involved in phosphogypsum research.

Research activities related to a few specific potential uses of phosphogypsum are discussed below. This is not intended as a complete listing of current or planned research projects. It is included here only to provide a perspective of the effort being made to

identify beneficial uses of phosphogypsum and to point out the diversity of the uses being considered.

3.7.1 Agricultural Uses

AGRO Services International, Inc., under a grant sponsored by FIPR, researched the use of phosphogypsum as a fertilizer on several Florida crops (AGRO89). As part of this study, field trials were conducted using various rates and placement of phosphogypsum (holding constant the addition of other fertilizer containing nutrients not found in gypsum) in order to determine the yield response of several crops to phosphogypsum. The study demonstrated that the application of phosphogypsum on crops, other than cowpeas, is very likely to result in strong economic returns.

Other research studies indicate that phosphogypsum can be an important source of calcium and sulfur for soils that are deficient in these elements (FIPR89b, FIPR90a, Da____). In a study of phosphogypsum as a source of sulfur to improve the yield of wheat grown for forage on sandy loams in Florida and Alabama, phosphogypsum was added at annual rates varying between 12 and 121 kg/acre (FIPR90a). Significant increases in yield were observed at an annual application rate of about 40 Kg/acre. Various studies have also indicated the usefulness of phosphogypsum on crops such as tobacco, corn, wheat, and sugar cane grown in Alabama, Louisiana, and North Carolina (Ba80, Go83).

Phosphogypsum has been found useful in controlling soil erosion and maintaining soil productivity on agricultural fields in the southeastern states where highly weathered soils have poor physical properties and are highly erodable (Mi89, Su80, Oa85). Experimental data indicate that phosphogypsum maintains a higher rate of water infiltration for soils compared with mined gypsum. Higher dissolution of the smaller phosphogypsum crystals provides a relatively high electrolyte concentration in the surface soil, sufficient to prevent crust formation. The improvement in water infiltration rates by phosphogypsum application has resulted in significant reductions in surface water runoff which leads to a reduction in soil erosion. Reductions in soil erosion approaching 60 percent have been observed (Wa89).

3.7.2 Construction Materials

Phosphogypsum use in road construction has been tested in the United States. Several research studies have demonstrated that phosphogypsum is suitable for use as a construction aggregate for various applications, including road construction, road embankments, and railroad beds (Ch89, Ch90). Phosphogypsum has been used on an experimental basis for paving and highway construction in both Texas and Florida (see Section 3.3). The addition of gypsum to cement appears to retard the setting times, counteracts shrinkage, increases the strength of the cement product, and provides resistance to sulfate etching.

Phosphogypsum has the same basic properties as natural gypsum and may be used as a substitute for natural gypsum in the manufacture of commercial construction products such

as plasterboard and plaster of Paris. Phosphogypsum has been used extensively in the manufacture of construction materials in Japan, Australia, and Europe. Currently, however, there are no major uses of phosphogypsum in commercial construction materials in the United States due to the low-cost availability of other suitable materials and to the ban on the utilization of phosphogypsum under 40 CFR Part 61, Subpart R. If the ban on the use of phosphogypsum is lifted, research might well lead to the development of building materials that are suitable for the U.S. market.

3.7.3 Purification of Phosphogypsum

The major disadvantage to the commercial use of phosphogypsum is the presence of potentially hazardous concentrations of radium-226. Research is being conducted in the United States and in other countries to reduce or remove the radium from raw phosphogypsum to ensure its safe use in the agriculture and construction industries. Methods for the removal of radium include hydrocycloning, a physical separation process, and calcining raw phosphogypsum into the hemihydrate form which eliminates most of the radium.

The physical process involves the use of a hydrocyclone to separate the smaller phosphogypsum crystals (less than 30 μm) which contain the greatest portion of the radionuclides from the rest of the phosphogypsum (Pe85). Although this process has proven effective in reducing radium concentrations by factors of 2 to 5, it does not remove all of the radium from the phosphogypsum. A new process, which shows promise of producing phosphogypsum of a much lower radioactive content, involves calcining the raw phosphogypsum into the hemihydrate form ($CaSO_4 \bullet 1/2H_2O$) and dissolving the hemihydrate in water (Mo90). The solution is quickly filtered and the radium salts are collected on the filter media.

Although the hemihydrate process generates a relatively low volume of waste, it is concentrated in radium-226, up to 600 pCi/g, and may pose disposal problems that are equal to or even greater than those associated with the original phosphogypsum (EPA90). No information is available on the volume or radium-226 concentration of the waste resulting from the physical separation method, but it too would probably produce wastes with relatively high concentrations of radium-226. This waste disposal problem will need to be resolved if the purification of phosphogypsum is to become viable.

3.8 SUMMARY OF PHOSPHOGYPSUM UTILIZATION

Probably less than 500,000 MT per year of phosphogypsum are being used in the United States today. The majority is for agricultural applications in California and the peanut producing states in the southeast (approximately 220,000 MT/year). The remaining quantity is for road construction in Texas and Florida (approximately 140,000 MT/yr). Quantities used for mine reclamation are not presently available, but could be substantial in the future if it were decided to dispose of the phosphogypsum by this process. The quantities

of phosphogypsum used for building materials and research are very small.

The historic usage of phosphogypsum from 1984 through 1987 shows a general decline, primarily due to the closing of the California facilities and the depletion of the phosphogypsum generated in that state. This decline is demonstrated in Table 3-2 (Jo88a, EPA89a).

Table 3-2. Estimated quantities of phosphogypsum used per year (EPA89a).

Year	Total Estimated MT[a]
1984	660,000
1985	460,000
1986	540,000
1987	360,000

[a] These totals are based on the results of a mail survey (Jo88a). Since some of the companies failed to respond to the survey, it does not represent a total response for the industry; however, it is believed that the survey gives an approximate total usage rate.

4. RADIOLOGICAL ASSESSMENTS OF PHOSPHOGYPSUM USE

4.1 INTRODUCTION

The purpose of this assessment is to analyze the radiological risk associated with various uses of phosphogypsum. The PATHRAE dose assessment model is employed to evaluate potential doses and risks for plausible exposure scenarios involving the commercial use of phosphogypsum. Section 4.3 provides a discussion of the methodology for this risk assessment, including a brief description of the PATHRAE dose assessment model, the exposure scenarios evaluated, and the input parameter values used in the PATHRAE analysis. The results of the risk assessment are summarized in Section 4.4. Risks to workers, to individuals in the critical population group (CPG), and to reclaimers are evaluated for agricultural, road construction, and research and development (R&D) uses of phosphogypsum.

There is some concern that crops grown in soils amended with phosphogypsum may contain elevated concentrations of radionuclides, primarily radium-226, polonium-210, and lead-210 (see Table 2-3). To better understand the significance of this pathway, both long- and short-term uptake studies were conducted at the University of Georgia for the EPA (Mi91). As part of the study, the leachability of radionuclides in amended soils was investigated. The results of the University of Georgia study are presented in Section 4.2.

4.2 RADIOLOGICAL EFFECT OF AMENDING SOILS WITH PHOSPHOGYPSUM

Both long- and short-term studies were conducted by the Agronomy Department at the University of Georgia to determine the significance of the uptake of radionuclides by plants grown in soils treated with phosphogypsum (Mi91). Locations having two different soil types were selected for study: one at Athens, GA where there is a sandy loam topsoil (25-30 cm) overlying a clayey subsoil, and at Tifton, GA where there is a very sandy topsoil (50 cm) over a sandy clay loam subsoil.

4.2.1 Long-Term Study

In 1985, 2 m by 5 m plots were established at both locations and treated with an equivalent of 4 MT/acre (simulating 5 to 10 years of field treatment) of phosphogypsum from Bartow, FL. The phosphogypsum was mixed with the top 15 cm of soil and planted with alfalfa. Similar untreated plots were used as controls. All plots were treated with commercial nitrogen, phosphorus, and potassium fertilizers. Plant tissues were randomly harvested from each plot in 1990, after which five core samples, 5 cm in diameter and 90 cm deep, were obtained from each plot, divided into three sections (0-15 cm, 15-30 cm, and 75-90 cm depths), and combined with respect to the depth increment.

4.2.2 Short-Term Study

This study was conducted in 1990 at the Athens, GA farm. Plots of 4 m by 5 m were treated with an equivalent of 4 MT/acre of the same phosphogypsum that was used in the long-term study. The phosphogypsum was lightly raked into the soil surface immediately after soybeans had been planted in June. Untreated plots were used as controls. The soybeans were harvested in the fall and separated into leaves (including stems) and seeds.

Prior to analysis, the plant samples were dried at 60°C and ground in a Wiley mill. The soil samples were air-dried and sieved to <2 mm. All samples, including samples of the phosphogypsum used in the studies, were analyzed for isotopic uranium and thorium, radium-226, lead-210, and polonium-210.

Of the pertinent radionuclides, only Ra-226 was consistently present above the detection limit in the soil samples; however, concentrations in samples from the treated plots were no higher than those from the control plots, about 2 pCi/g. The analysis of core samples from fields treated five years earlier with phosphogypsum showed no detectable elevated levels of radionuclides at any depth. These results were attributed to the small quantities of radionuclides added in the phosphogypsum relative to the amounts naturally present in the soil.

Radium-226 was the only radionuclide associated with phosphogypsum that was detected in either alfalfa or soybeans. There were no statistical differences in the concentration of Ra-226 measured in plant tissues grown in the treated and control plots. Although the uptake of Ra-226 was measurably higher in alfalfa grown in Tifton soil than in alfalfa grown in Athens soil (2 pCi/g dry weight vs less than 1 pCi/g dry weight), it was not statistically significantly greater in plants from treated soils than in the controls at the two sites. The dominant radionuclide was potassium-40 in both plant types, ranging from about 7 to 20 pCi/g dry weight.

4.2.3 Leaching Studies

A series of leaching studies was performed as part of the uptake studies (Mi91). Intact soil columns, 10 cm diameter and 30 cm deep, were taken of both Tifton and Athens soils using a truck-mounted hydraulic ram. Two columns of each soil type were treated with an equivalent of 4 MT/acre of the phosphogypsum used in the uptake studies. The phosphogypsum was applied as a powder to the soil surface. Two columns of each soil type were untreated and used as controls. Deionized water was ponded on the surface at a constant 2-cm depth and allowed to perculate through the column until a total of 8 liters of leachate in 1-liter increments had been collected from the column base. This is equivalent to about one year of precipitation.

The leachate was filtered to remove suspended clay particles prior to analysis. The columns were cut into 5-cm sections, and the soil in each section analyzed separately for the

same radionuclides as listed above for the soil samples.

Only Ra-226 was consistently detected in the leachate of the soil columns. The amount of Ra-226 leached from the treated and untreated Athens soil columns was about the same, totaling 2.2 pCi in the 8 liters collected. However, the Ra-226 concentrations in the leachate of Tifton soil treated with phosphogypsum was 3 to 5 times higher than in the control leachate. The Ra-226 concentration in the leachate peaked at 3 liters (0.8 pCi/L), and then decreased to near the control level after 8 liters were collected. The total amount of Ra-226 collected in the Tifton soil leachate was 6.5 pCi, equivalent to about 5 percent of the Ra-226 initially added in the phosphogypsum. The higher leachability of Ra-226 in the Tifton soil was attributed to the sandy nature of the soil allowing rapid percolation of water with limited adsorption capacity of the soil. No discernable trend was observed in the Ra-226 concentration with soil depth.

Considering the relative immobility of the principal radionuclides associated with phosphogypsum in soil and the small quantities added in the phosphogypsum relative to the amounts naturally present in the soil, 0.7 pCi/g and 1.9 pCi/g of radium-226 in Tifton and Athens soils, respectively, University of Georgia investigators concluded that short-term treatments (5-10 years) of farm lands with phosphogypsum does not pose an acute environmental hazard.

Studies conducted earlier to characterize the radiological hazards associated with soils amended with phosphogypsum produced similar results and conclusions. A University of Florida study of radionuclide uptake by foods grown in soil receiving one ton of phosphogypsum per acre every four years concluded that there would be no significant radiation problems for up to at least 50 years (Ro88). Another study measured the radon flux on three fields that had been amended with varying amounts of phosphogypsum for different periods of time (Po90). The mean of 13 flux measurements, using charcoal canisters, made on each field ranged from 0.4 to 1 pCi/m^2-s. The background flux, measured on areas receiving no application, was 0.4 pCi/m^2-s. It was difficult to correlate the radon flux measurements with the amount of phosphogypsum applied.

4.3 RISK ASSESSMENT METHODOLOGY

The methodology employed in evaluating individual and population risks from commercial uses of phosphogypsum is described in this section. Dose calculations were performed using the PATHRAE dose assessment model (EPA87). Calculations were performed for exposure scenarios which included the use of phosphogypsum in agriculture, road construction, and R&D activities. Where PATHRAE does not model the exposure scenario (e.g., a person performing experimental analyses on phosphogypsum contained in metal drums), the MICROSHIELD computer code (GRO85) was used to augment the results of the PATHRAE analyses. Lifetime risks from one year of exposure were obtained from the PATHRAE dose assessment results using the risk conversion factors in the EPA's Environmental Impact Statement for NESHAPS radionuclides (EPA89b).

4.3.1 The PATHRAE Dose Assessment Model

The PATHRAE performance assessment model (EPA87) was initially developed as an analytical tool to assist EPA in developing standards for low-level radioactive waste and below regulatory concern waste disposal. The PATHRAE model estimates health effects which could potentially occur if radioactive wastes were disposed of in a near surface facility, sanitary landfill, or other geological setting. PATHRAE can be used to calculate effective dose equivalents[a] to members of a critical population group from the disposal of radioactive material at sites located in diverse hydrogeologic, climatic, and demographic settings. An important PATHRAE model feature is its simplicity in analyzing a comprehensive set of radionuclides, disposal settings, and exposure pathways. The effects of changes in disposal site and facility characteristics can be readily investigated with relatively few parameters needed to define the problem.

PATHRAE models both off-site and on-site pathways through which persons may come in contact with radioactivity from disposed material. The off-site pathways include groundwater transport to a well and a river, surface water runoff to a river, and atmospheric transport of radioactive particulates. On-site pathways include direct gamma exposure, dust inhalation, exposure from foodstuffs grown on-site, and inhalation of radon gas and radon daughters. See Appendix A for a detailed description of the PATHRAE pathway equations.

For this risk assessment, the phosphogypsum is assumed to be mixed with soil in an agricultural field or mixed with other construction materials to construct roadbeds and concrete highways. Exposure scenarios and values for some important input parameters used in modeling these scenarios are described later in this section.

4.3.2 The MICROSHIELD Computer Code

Where the exposure geometry is not readily modeled by PATHRAE (e.g., person exposed to the radioactivity in phosphogypsum contained in metal drums), MICROSHIELD was used to estimate the external gamma dose. MICROSHIELD (GRO85) is a microcomputer adaptation of the ISOSHLD II (Eng66) mainframe code for analyzing gamma radiation shielding. MICROSHIELD has solution algorithms for 14 different geometries which include point, line, sphere, disk, cylinder, plane, and rectangular volume sources; and slab, cylindrical, and spherical shield configurations. MICROSHIELD sorts individual gamma energies from each isotope in the source term into 21 energy groups. Dose rate calculations are performed by one of three geometry-based calculational routines which include analytical expressions, Simpson's rule integration, and point-kernel integration. Execution of the program proceeds by repeating the solution algorithm for each energy group that has any activity until all 21 energy groups have been evaluated.

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[a] Throughout this report the term "dose" refers to the effective whole body dose equivalent.

The MICROSHIELD code user supplies input information describing the characteristics of the exposure scenario to be evaluated. This input information includes: distance between the source and the exposed individual; source inventory; dimensions of the source region; the dimensions, locations, and orientations of intervening shields; and the material (including air) used for these intervening shields.

4.3.3 Exposure Scenarios

The exposure scenarios evaluated for this phosphogypsum risk assessment include potential exposures to individuals from the use of phosphogypsum in agriculture, road construction, and R&D activities.

4.3.3.1 Phosphogypsum in Agriculture

Seven scenarios involving the agricultural use of phosphogypsum are evaluated. Scenarios 1, 3, and 5 assume a clay soil base type, with the exposed individual being greater than 100 m from the site edge. Scenarios 2, 4, and 6 consider similar pathways, using a sand soil base type, and exposed individuals 100 m from the site boundary. Scenarios 1 through 4 involve the use of phosphogypsum as a source of calcium and sulfur for soils deficient in these elements. Scenarios 5 and 6 involve its use in sediment control for soils that have been eroded and leached. Scenario 7 evaluates the effect of using phosphogypsum containing a range of Ra-226 concentrations with different application rates.

Scenarios 1 through 4: Phosphogypsum as a source of calcium and sulfur for soils deficient in these elements. Parameters which characterize the four scenarios involving phosphogypsum as a source of calcium and sulfur on agricultural fields are shown in Table 4-1. Four scenarios are evaluated: two involving an average phosphogypsum application rate on a moderate size clay or sand field, and another for a maximum application rate on a large clay or sand field. The parameter values in Table 4-1 are based on responses by agricultural users of phosphogypsum to a survey by The Fertilizer Institute (TFI). The reference agricultural fields for Scenarios 1 through 4 are postulated to be located in the southeastern United States. Values of environmental and climatological parameters used in the risk assessment are representative of a humid permeable site.

The dose calculations for Scenarios 1 through 4 assume biennial applications of phosphogypsum to the reference site for a period of 100 years. Phosphogypsum is spread over a field and diluted by mixing with the soil. Hence the incremental radionuclide concentrations in the soil are much lower than the concentrations in the phosphogypsum itself. Over time, as phosphogypsum continues to be applied, the radionuclide concentrations in the soil are expected to increase until equilibrium is reached with competing mechanisms that remove the gypsum, and its radioactive constituents, from the soil. These removal mechanisms include plant uptake, leaching by infiltration of surface water, and wind and water erosion. The radionuclide content in the soil is also reduced as a result of radioactive decay. A simple mass balance equation is used to estimate radionuclide concentrations in the

Table 4-1. Phosphogypsum use parameters for Scenarios 1 through 4.

	Average Site (Scenario 1&2)	Maximum Site (Scenario 3&4)
Kilograms of phosphogypsum per acre	664	2,032
Acres per farm	138	1,000
Tillage depth (cm)	22	46
Application rate	Biennially	Biennially
Distance to nearest residence (m)	890 & 100	6,440 & 100
Soil Type	Clay, Sand	Clay, Sand

reference soil as a result of biennial applications of phosphogypsum for a period of 100 years. For a Ra-226 concentration of 30 pCi/g in phosphogypsum, the increase in the Ra-226 concentration in the soil after 100 years of biennial application is calculated to be 0.69 pCi/g for Scenarios 1 and 2 and 1.02 pCi/g for Scenarios 3 and 4. A detailed description of the Ra-226 soil concentration calculation method is presented in Appendix B.

Scenarios 5 and 6: Phosphogypsum as sediment control for soils that have been eroded and leached. Parameters which characterize Scenarios 5 and 6 are shown in Table 4-2. The reference agricultural site for this scenario is assumed to be located in south-central California. The phosphogypsum is initially applied at the rate of 8 MT per acre, followed by biennial applications of 4 MT per acre. As in Scenarios 1 through 4, an application period of 100 years is postulated. For a Ra-226 concentration of 30 pCi/g in phosphogypsum, the increase in the Ra-226 concentration in the soil after 100 years of biennial application is calculated to be 3.12 pCi/g for Scenarios 5 and 6.

For Scenarios 1 through 6 the following exposure pathways are evaluated:

- <u>Agricultural Worker</u>
  - Direct gamma exposure
  - Dust inhalation

- <u>On-site Individual</u>
  - Direct gamma exposure
  - Indoor radon inhalation
  - Use of contaminated well water

- <u>Member of CPG</u>
  - Inhalation of contaminated dust
  - Ingestion of drinking water from a contaminated well
  - Ingestion of foodstuffs contaminated by well water
  - Ingestion of foodstuffs grown on fertilized soil

- <u>Off-Site Individual</u>
  - Ingestion of river water contaminated via the groundwater pathway
  - Ingestion of river water contaminated by surface runoff.

Table 4-2. Phosphogypsum use parameters for Scenarios 5 and 6.

Kilograms of phosphogypsum per acre	
- Initial application	8,000
- Subsequent applications	4,000
Acres per farm	556
Tillage depth (cm)	30
Application rate	biennially
Distance to nearest residence (m)	1,000 & 100
Soil Type	Clay, Sand

The agricultural worker is assumed to spend 2,000 hours per year at the agricultural site, performing activities such as plowing, fertilizing, harvesting, etc. The worker would probably use machinery for most of these activities which would provide some shielding from direct gamma radiation (as in the construction scenarios plowing equipment on average provide a shielding factor of 0.6). However, to ensure conservatism in the results of this risk analysis, no credit for shielding is taken in calculating the dose from direct exposure to gamma radiation.

The on-site individual is assumed to live in a house in a development constructed on a site which was previously used for agriculture. For conservatism, this individual is also assumed to work at this same site.

The CPG is defined to include individuals who might be exposed to the highest doses as a result of normal daily activities. For this phosphogypsum risk assessment, the member of the CPG is assumed to be an adult at the nearest residence as defined in Tables 4-1 and 4-2. The person obtains all water from a well adjacent to the house. Fifty percent of foodstuffs are assumed to be grown on-site.

Scenario 7: Use of phosphogypsum as a soil amendment based on the application rate and Ra-226 concentration. The purpose of this scenario is to determine if the phosphogypsum containing various concentrations of Ra-226 can be applied for agricultural purposes based on various application rates. To evaluate the feasibility of this approach, risk estimates are performed for the two limiting exposure pathways identified from Scenarios 1-6, direct gamma and indoor radon exposures to the on-site individual. The risks for these exposure pathways are estimated using the following combinations of phosphogypsum application rates and Ra-226 concentrations:

Application Rate (lbs/acre)	Ra-226 Concentration (pCi/g)
500	3, 7, 15, 20, 30, 45, 60
1,000	3, 7, 15, 20, 30, 45
1,500	3, 7, 15, 20, 30
2,500	3, 7, 15, 20
5,000	3, 7, 15
10,000	3, 7, 15

A nine-inch tillage depth is assumed. All other parameters remain constant and are those given above for the average site in the southeastern United States.

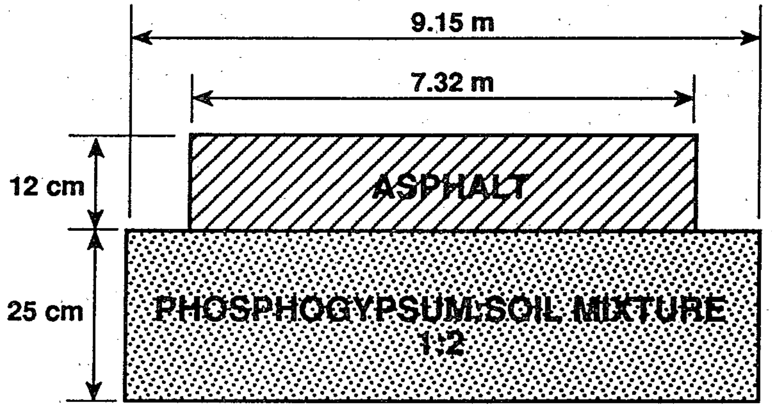
4.3.3.2 Phosphogypsum in Road Construction

Four scenarios involving phosphogypsum in road construction are evaluated. Scenarios 8 and 9 involve the use of phosphogypsum in a road base for a secondary road. Scenarios 10 and 11 involve phosphogypsum as an additive to increase the strength of a concrete road surface. These scenarios are shown schematically in Figure 4-1.

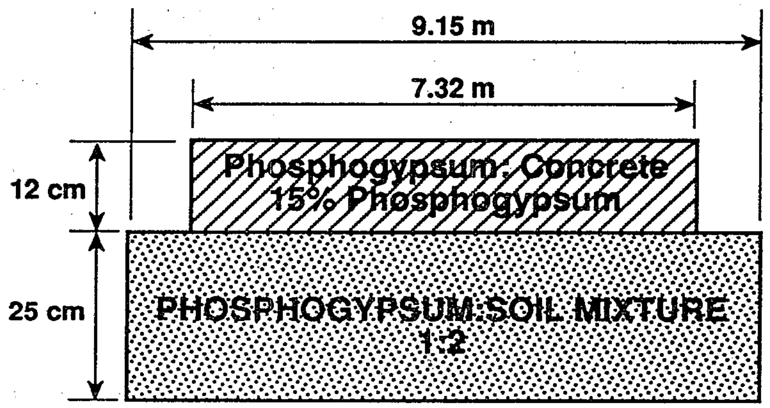
Scenarios 8 and 9: Phosphogypsum in a road base for a secondary road. The road base consists of a 1:2 phosphogypsum:soil mixture with a density of 2.25 g/cm^3 (2.25 MT/m^3). Assuming a Ra-226 concentration of 30 pCi/g in phosphogypsum, the Ra-226 concentration in the road base is 10 pCi/g. The road base is 9.15 m (30 ft) wide and 0.25 m (10 inches) thick and is covered by a 0.12 m (5 inch) thickness of asphalt.

Scenarios 10 and 11: Phosphogypsum in a concrete road surface. The concrete road surface incorporates 15 weight percent phosphogypsum. Assuming a Ra-226 concentration of 30 pCi/g in phosphogypsum, the Ra-226 concentration in the road surface is 4.5 pCi/g. The road surface is 7.32 m (24 ft) wide and 0.12 m (5 inches) thick. The road base under the concrete surface is the same as for Scenarios 8 and 9.

For Scenarios 8 through 11 the following exposure pathways are evaluated:



SCENARIOS 8 AND 9
USE OF PHOSPHOGYPSUM IN A ROAD BASE



SCENARIOS 10 AND 11
USE OF PHOSPHOGYPSUM IN A
CONCRETE ROAD SURFACE

RAE-103855

Figure 4-1. Scenarios involving the use of phosphogypsum in road construction.

- <u>Construction Worker</u>
  - Direct gamma exposure
  - Dust inhalation

- <u>Person Driving on Road</u>
  - Direct gamma exposure

- <u>Member of CPG</u>
  - Direct gamma exposure
  - Ingestion of drinking water from a contaminated well
  - Ingestion of foodstuffs contaminated by well water

- <u>Reclaimer</u>
  - Direct gamma exposure
  - Indoor radon inhalation
  - Use of contaminated well water
  - Ingestion of foodstuffs grown on-site

- <u>Off-Site Individual</u>
  - Ingestion of river water contaminated via the groundwater pathway
  - Ingestion of river water contaminated by surface runoff.

The construction worker is assumed to be engaged eight hours per day for 250 days per year in constructing a 16-km (10-mile) section of road. Gamma exposures are calculated for a worker who is employed directly on the road surface and a worker who uses equipment such as a bulldozer or road grader which provides some shielding from gamma radiation. The shielding coefficient is 0.6.

The person driving on the road is assumed to use the road from home to work, and return. This person travels the road one hour per day for 250 trips per year. The automobile in which this person rides provides some shielding from direct gamma radiation. The shielding coefficient is 0.6.

The reclaimer is assumed to build a house on the roadbed at some future time after the road is closed and the road surface has crumbled and been removed. In addition to living in a house at the site, the reclaimer drills a well for water and plants a vegetable garden in the contaminated soil. The vegetable garden provides 50 percent of the reclaimer's foodstuffs.

The member of the CPG is assumed to live in a house located 100 or 1,000 meters from the road. Potential doses to a member of the CPG could result from direct gamma exposure or from the use of contaminated well water.

4.3.3.3 Phosphogypsum in Research & Development Activities

One scenario (Scenario 12) is evaluated in which phosphogypsum is used in research and development to evaluate the properties of this material for commercial applications. In this scenario, exposures are estimated for a worker who spends four hours per day, 250 days per year in a laboratory containing one open 55-gallon drum of phosphogypsum. The worker is exposed via direct gamma radiation, dust inhalation, and radon inhalation pathways. MICROSHIELD is used to estimate the external gamma dose; the worker is assumed to be positioned at an average distance of one meter from the drum of phosphogypsum. To estimate the exposure from dust inhalation, a dust loading of 100 micrograms/m^3 is postulated. This value is derived from 40 CFR 50.6(b), which specifies a level of 50 μg/m^3 as the arithmetic mean level of primary and secondary standards for airborne particulate matter. The value is doubled to provide a conservative estimate. To estimate the indoor radon exposure, two air changes per hour are assumed.

4.3.4 Input Parameters

Values of input parameters used in PATHRAE to evaluate potential doses to individuals and the attendant risks from the commercial use of phosphogypsum are presented in this section. These input parameters include radionuclide concentrations, dose and risk conversion factors, and parameters used to characterize the exposure scenarios described in Section 4.3.3.

4.3.4.1 Radionuclide Concentrations

The relative radionuclide concentrations in phosphogypsum providing the basis for the risk assessment are shown in Table 4-3. The concentrations in Table 4-3 are based on a radium-226 concentration of 1 pCi/g. The risk estimates presented in Section 4 are given as a function of Ra-226 concentration.

The relative concentrations of Pb-210, Po-210, Th-230, U-234, and U-238 are based on average activity ratios of these radionuclides to Ra-226 in phosphogypsum reported in Ho88. The relative concentration of Ra-228 is derived from the activity ratio of Ra-228 to Ra-226 in phosphate fertilizer, reported in SCA91. Activity ratios for Th-228 and Th-232 relative to Ra-226 are also those for phosphate fertilizer, reported in SCA91. Because concentrations of thorium in phosphogypsum are depleted relative to concentrations in phosphoric acid, the use of thorium to radium-226 activity ratios for phosphate fertilizer may tend to overestimate these thorium concentrations. The activity of U-235 in phosphogypsum is assumed to be about 5 percent of the U-238 activity.

4.3.4.2 Dose and Risk Conversion Factors

The dose and risk conversion factors used in this analysis are shown in Table 4-4. Dose conversion factors for ingestion and inhalation are from the EPA's Federal Guidance

Table 4-3. Phosphogypsum reference radionuclide concentrations.[a]

Radionuclide	Concentration (pCi/g)
Ra-226	1.000
Po-210	1.040
Pb-210	1.400
Th-228	0.133
Ra-228	0.133
Th-230	0.187
Th-232	0.123
U-234	0.120
U-235	0.005
U-238	0.110

[a] Based on a Ra-226 concentration of 1 pCi/g. See text for explanation of activity ratios of other radionuclides relative to Ra-226.

Report No. 11, which provides guidance for control of occupational exposures to radiation (EPA88).

Dose conversion factors for inhalation, ingestion and direct exposure to gamma radiation are from guidance for modifying PRESTO-EPA-CPG to reflect major recent changes in EPA's dose calculation methodology. The inhalation and ingestion conversion factors represent the effective whole body dose equivalents resulting from a unit curie of intake, and the conversion factors for the direct gamma represent the effective whole body dose rates resulting from the exposure to a unit concentration of a curie per square meter on the ground surface. Risk conversion factors in Table 4-4, except those for radon, are based on the radiation risk factors in Table 6-27 of Volume I of EPA's "Environmental Impact Statement for NESHAPS Radionuclides" (EPA89b). As a result of a recommendation by EPA's Science Advisory Board, EPA reduced the radon risk conversion factors by about 37 percent to 4.4×10^{-8} and 4.4×10^{-9} for indoor and outdoor exposures, respectively (Co92). The risk conversion factors represent average lifetime (i.e., 70-year) risks of fatal cancer per unit

Table 4-4. Dose and risk conversion factors.

I. DOSE CONVERSION FACTORS

Nuclide	Inhalation DCF (mrem/pCi)[a]	Ingestion DCF (mrem/pCi)[a]	Direct Gamma DCF (mrem/yr per pCi/m^2)
Ra-226	8.6E-03	1.3E-03	1.67E-04
Po-210	9.4E-03	1.9E-03	8.55E-10
Pb-210	1.4E-02	5.4E-03	0
Th-228	3.4E-01	4.0E-04	3.37E-04
Ra-228	4.8E-03	1.4E-03	9.04E-05
Th-230	3.3E-01	5.5E-04	8.88E-08
Th-232	1.6E+00	2.7E-03	6.56E-08
U-234	1.3E-01	2.8E-04	8.00E-08
U-235	1.2E-01	2.5E-04	6.41E-08
U-238	1.2E-01	2.7E-04	1.67E-05

(a) 50-year committed dose equivalent from one year of intake (uptake).

II. RISK CONVERSION FACTORS[b]

Nuclide	Inhalation Risk per pCi Inhaled	Ingestion Risk per pCi Ingested	Direct Gamma Risk per pCi/m^2
Ra-226	2.8E-09	9.4E-11	5.7E-11
Po-210	2.4E-09	1.4E-10	2.9E-16
Pb-210	1.4E-09	5.5E-10	0
Th-228	7.2E-08	1.3E-11	4.8E-11
Ra-228	5.8E-10	7.0E-11	3.1E-11
Th-230	2.9E-08	2.3E-11	2.7E-14
Th-232	2.9E-08	2.1E-11	2.0E-14
U-234	2.5E-08	7.5E-11	2.4E-14
U-235	2.3E-08	7.3E-11	5.5E-12
U-238	2.2E-08	7.4E-11	7.23E-13

(b) 70-year lifetime risk of fatal cancer from one year of exposure.

III. RADON RISK CONVERSION FACTORS[c]

Exposure Scenario	Inhalation Risk per pCi/m^3
Indoor Exposure	4.4E-08
Outdoor Exposure	4.4E-09

(c) 70-year lifetime risk of fatal cancer from one year of exposure to Rn-220 and Rn-222 daughters.

of intake or exposure. A quality factor of 1 has been used to convert from rads to rems for low-LET (i.e., gamma) radiation, and a relative biological effectiveness of 8 has been used to convert from rads to rems for the induction of cancer by high-LET (i.e., alpha) radiation.

4.3.4.3 Site-Specific Input Parameters

Values of all important site-specific input parameters used by PATHRAE in the risk assessments are shown in Table 4-5.

4.4 RESULTS

The results of the phosphogypsum risk assessment are given in this section. Results are presented for the commercial use of phosphogypsum in agriculture, road construction, and research and development. Exposure scenarios used for this risk assessment are described in Section 4.3.

4.4.1 Phosphogypsum in Agriculture

The results of the risk assessment for the use of phosphogypsum in agriculture are summarized in Tables 4-6 through 4-14. Estimated doses and risks for Scenarios 1 and 2, involving an average phosphogypsum application rate on a moderate size clay or sand field used to grow peanuts, are shown in Tables 4-6 and 4-7. Estimated doses and risks for Scenarios 3 and 4, involving a maximum phosphogypsum application rate on a large clay or sand field, are shown in Tables 4-8 and 4-9. Estimated doses and risks for Scenarios 5 and 6, involving the use of phosphogypsum for sediment control, are shown in Tables 4-10 and 4-11. Estimated risks for Scenario 7, based on various phosphogypsum application rates and Ra-226 concentrations, for radon and gamma exposures to the on-site individual are shown in Tables 4-12 and 4-13, respectively; the total risks from both pathways are shown in Table 4-14. The risks shown in the tables are estimated lifetime (70-year) risks from one year of exposure.

As explained in Section 4.3, phosphogypsum applications to agricultural fields are assumed to occur biennially. Equilibrium is reached with competing mechanisms that remove gypsum and its radioactive constituents at 1100 yrs for Ra-226 and 1600 yrs for uranium and thorium. Doses and risks are evaluated for fields that have been repeatedly fertilized on a biennial basis over a 100-year period. Results of Scenarios 1 through 6 are shown for Ra-226 concentrations in phosphogypsum ranging from 26 pCi/g to 3 pCi/g. The actual Ra-226 concentrations in the agricultural fields are lower due to dilution of the phosphogypsum with the soil and depletion mechanisms such as plant uptake and leaching which tend to remove radionuclides.

Table 4-5. Site-specific input parameters for PATHRAE risk assessments.

Parameter	Units	Clay Value, Sand Value
Phosphogypsum application rate--agricultural scenarios		
Fertilizer--average	MT/acre/yr	0.66
Fertilizer--maximum	MT/acre/yr	2.03
Soil conditioner	MT/acre/yr	4.05
Phosphogypsum application interval--agricultural scenarios	--	biennially
Total years of application--agricultural scenarios	yrs	100
Agricultural field size		
Fertilizer--average	acre	138
Fertilizer--maximum	acre	1,000
Soil conditioner	acre	556
Tillage depth--agricultural scenarios		
Fertilizer--average	m	0.22
Fertilizer-maximum	m	0.46
Soil conditioner	m	0.30
Agricultural field soil density	kg/m^3	1.50E+03
Roadbed material density	kg/m^3	2.25E+03
Distance to nearest residence		
Fertilizer--average	m	890, 100
Fertilizer--maximum	m	6,440, 100
Soil conditioner	m	1,000, 100
Road construction scenarios	m	1,000, 100
Distance to river	m	5.00E+03
River flow rate	m^3/yr	1.00E+08
Density of aquifer	kg/m^3	1.80E+03
Porosity of aquifer	--	0.33
Horizontal velocity of aquifer	m/yr	20

Table 4-5. Site-specific input parameters for PATHRAE risk assessments (continued).

Parameter	Units	Clay Value, Sand Value
Vertical distance to aquifer		
Fertilizer scenarios	m	3.0
Soil conditioner scenario	m	10.0
Construction scenarios--humid site	m	3.0
Construction scenarios--dry site	m	10.0
Water infiltration rate		
Fertilizer scenarios	m/yr	0.40
Soil conditioner scenario	m/yr	0.25
Construction scenarios--humid site	m/yr	0.40
Construction scenarios--dry site	m/yr	0.25
Fraction of food eaten grown on-site	--	0.50
Adult breathing rate	m^3/yr	8.00E+03
Average dust loading in outside air	kg/m^3	5.00E-07
Average dust loading in R&D lab	kg/m^3	1.00E-07
Atmospheric stability class	--	4
Fraction of time wind blows toward receptor	--	0.093
Average wind speed	m/sec	4.5
Dust resuspension rate for off-site transport	m^3/sec	5.0E-07
Dust deposition velocity	m/sec	1.0E-03
Radon emanating power	--	0.30
Radon diffusion coefficient		
Soil--humid site	m^2/yr	2.2E+01
Soil--dry site	m^2/yr	6.3E+01
Concrete	m^2/yr	1.6E+01
Air change rate in reclaimer house	changes/hr	2
Exposure fraction for indoor exposure	--	0.75
Equivalent exposure fraction for outdoor exposure	--	0.50
Surface erosion rate	m/yr	2.0E-04

Table 4-5. Site-specific input parameters for PATHRAE risk assessments (continued).

Parameter	Units	Clay Value, Sand Value
Distribution coefficients (K_d)		
Ra-226	m^3/kg	0.45, 0.07
Po-210	m^3/kg	0.50, 0.50
Pb-210	m^3/kg	0.90, 0.90
Th-228	m^3/kg	150.0, 150.0
Ra-228	m^3/kg	0.45, 0.07
Th-230	m^3/kg	150.0, 150.0
Th-232	m^3/kg	150.0, 150.0
U-234	m^3/kg	0.45, 0.07
U-235	m^3/kg	0.45, 0.07
U-238	m^3/kg	0.45, 0.07
Volume of drinking water consumed annually by an individual	m^3/yr	0.37
Length of road perpendicular to aquifer	mile	10
Aquifer thickness	m	10

It is observed that the doses from the groundwater pathways are all zero. As an added sensitivity analysis, scenarios 2, 4, 6, 9 and 11 were created as replicates of 1, 3, 5, 8 and 10, modifying the distance to the offsite individual (100 m). Additionally, the k_d for uranium and radium was reduced to 70 ml/g. Using these modifications, PATHRAE projected a peak risk at year 4200 of 1.5×10^{-8}. These changes also caused, as illustrated in the summary tables, an increase in the risk to members of the CPG from dust inhalation. For a well placed onsite, and a k_d of 70 ml/g for uranium and radium, a risk of 6.7×10^{-9} occurred by the year 1000, for scenario 4. A peak risk of 2×10^{-8} occurred in year 3100 for the same scenario.

For Scenarios 1 and 2, a Ra-226 concentration of 26 pCi/g in phosphogypsum is estimated to correspond to an increase in the soil Ra-226 concentration of 0.60 pCi/g at the end of the 100-year period. For Scenarios 3 and 4, a Ra-226 concentration of 26 pCi/g in phosphogypsum is estimated to correspond to an increase in the soil Ra-226 concentration of 0.88 pCi/g at the end of the 100-year period. For Scenarios 5 and 6, a Ra-226 concentration of 26 pCi/g in phosphogypsum is estimated to correspond to an increase in the soil Ra-226 concentration of 2.70 pCi/g at the end of the 100-year period. As shown in the tables, for each scenario, the doses and risks are directly proportional to the Ra-226 concentration in the original phosphogypsum.

Table 4-6. Risk assessment results for Scenario 1 - use as fertilizer - average site (clay).

	Ra-226 Concentrations in Phosphogypsum									
	26 pCi/g		10 pCi/g		7 pCi/g		5 pCi/g		3 pCi/g	
	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]
Agricultural Worker Direct Gamma	3.5E+00	1.4E-06	1.4E+00	5.3E-07	9.5E-01	3.7E-07	6.8E-01	2.7E-07	4.1E-01	1.6E-07
Agricultural Worker Dust Inhalation	7.1E-02	5.8E-09	2.7E-02	2.2E-09	1.9E-02	1.6E-09	1.4E-02	1.1E-09	8.2E-03	6.7E-10
On-Site Individual Direct Gamma	7.6E+00	3.0E-06	2.9E+00	1.2E-06	2.0E+00	8.0E-07	1.4E+00	5.7E-07	8.7E-01	3.4E-07
On-Site Individual Indoor Radon	---	2.6E-06	---[c]	1.0E-06	---	6.8E-07	---	5.0E-07	---	3.0E-07
On-Site Individual Well Water Use	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Inhalation of contaminated dust	7.0E-04	5.7E-11	2.7E-04	2.2E-11	1.9E-04	1.6E-11	1.4E-04	1.1E-11	8.1E-05	6.7E-12
Member of CPG - Ingestion of drinking water from contaminated well	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Ingestion of foodstuff contaminated by well water	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Ingestion of foodstuff grown on fertilized soil	4.9E-02	5.2E-09	1.9E-02	2.0E-09	1.3E-02	1.4E-09	9.5E-03	1.5E-09	5.7E-03	3.0E-10
Individual - Ingestion of river water contaminated by groundwater	---[c]	---[c]	---	---	---	---	---	---	---	---
Individual - Ingestion of river water contaminated by surface runoff	8.3E-03	7.4E-10	3.2E-03	2.9E-10	2.2E-03	2.0E-10	1.6E-03	1.4E-10	9.6E-04	8.6E-11

a. Dose or dose commitment from one year of exposure.
b. Lifetime risk from one year of exposure.
c. No radionuclides are calculated to reach the on-site well via the groundwater pathway for almost 10,000 years, or the off-site river or well for at least 100,000 years because of groundwater velocities and retardation factors.

Table 4-7. Risk assessment results for Scenario 2 - use as fertilizer - average site (sand).

	Ra-226 Concentrations in Phosphogypsum									
	26 pCi/g		10 pCi/g		7 pCi/g		5 pCi/g		3 pCi/g	
	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]
Agricultural Worker Direct Gamma	3.5E+00	1.4E-06	1.4E+00	5.3E-07	9.5E-01	3.7E-07	6.8E-01	2.7E-07	4.1E-01	1.6E-07
Agricultural Worker Dust Inhalation	7.1E-02	5.8E-09	2.7E-02	2.2E-09	1.9E-02	1.6E-09	1.4E-02	1.1E-09	8.2E-03	6.7E-10
On-Site Individual Direct Gamma	7.6E+00	3.0E-06	2.9E+00	1.2E-06	2.0E+00	8.0E-07	1.4E+00	5.7E-07	8.7E-01	3.4E-07
On-Site Individual Indoor Radon	---	2.6E-06	---[c]	1.0E-06	---	6.8E-07	---	5.0E-07	---	3.0E-07
On-Site Individual Well Water Use	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Inhalation of contaminated dust	4.0E-02	3.3E-09	1.5E-02	1.3E-09	1.1E-02	8.8E-10	7.7E-03	6.3E-10	4.6E-03	3.8E-10
Member of CPG - Ingestion of drinking water from contaminated well	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Ingestion of foodstuff contaminated by well water	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Ingestion of foodstuff grown on fertilized soil	4.9E-02	5.2E-09	1.9E-02	2.0E-09	1.3E-02	1.4E-09	9.5E-03	1.5E-09	5.7E-03	3.0E-10
Individual - Ingestion of river water contaminated by groundwater	---[c]	---[c]	---	---	---	---	---	---	---	---
Individual - Ingestion of river water contaminated by surface runoff	8.3E-03	7.4E-10	3.2E-03	2.9E-10	2.2E-03	2.0E-10	1.6E-03	1.4E-10	9.6E-04	8.6E-11

a. Dose or dose commitment from one year of exposure.
b. Lifetime risk from one year of exposure.
c. No radionuclides are calculated to reach the on-site well via the groundwater pathway for about 4,000 years, or the off-site river or well for at least 100,000 years because of groundwater velocities and retardation factors.

Table 4-8. Risk assessment results for Scenario 3 - use as fertilizer - maximum site (clay).

	Ra-226 Concentrations in Phosphogypsum									
	26 pCi/g		10 pCi/g		7 pCi/g		5 pCi/g		3 pCi/g	
	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]
Agricultural Worker Direct Gamma	5.4E+00	2.2E-06	2.1E+00	8.1E-07	1.5E+00	5.7E-07	1.0E+00	4.1E-07	6.2E-01	2.5E-07
Agricultural Worker Dust Inhalation	1.1E-01	9.0E-09	4.2E-02	3.5E-09	3.0E-02	2.4E-09	2.1E-02	1.7E-09	1.3E-02	1.0E-09
On-Site Individual Direct Gamma	1.2E+01	4.6E-06	4.4E+00	1.8E-06	3.1E+00	1.3E-06	2.2E+00	8.7E-07	1.3E+00	5.2E-07
On-Site Individual Indoor Radon	---	6.8E-06	---[c]	2.6E-06	---	1.8E-06	---	1.3E-06	---	7.5E-07
On-Site Individual Well Water Use	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Inhalation of contaminated dust	4.4E-05	3.6E-12	1.7E-05	1.4E-12	1.2E-05	9.6E-13	8.5E-06	6.9E-13	5.1E-06	4.1E-13
Member of CPG - Ingestion of drinking water from contaminated well	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Ingestion of foodstuff contaminated by well water	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Ingestion of foodstuff grown on fertilized soil	8.6E-02	9.1E-09	3.3E-02	3.5E-09	2.3E-02	2.5E-09	1.6E-02	1.8E-09	9.9E-03	1.1E-09
Individual - Ingestion of river water contaminated by groundwater	---[c]	---[c]	---	---	---	---	---	---	---	---
Individual - Ingestion of river water contaminated by surface runoff	8.8E-02	7.8E-09	3.4E-02	3.0E-09	2.4E-02	2.1E-09	1.7E-02	1.5E-09	1.0E-02	9.1E-10

a. Dose or dose commitment from one year of exposure.
b. Lifetime risk from one year of exposure.
c. No radionuclides are calculated to reach the on-site well via the groundwater pathway for almost 10,000 years, or the off-site river or well for more than 100,000 years because of groundwater velocities and retardation factors.

Table 4-9. Risk assessment results for Scenario 4 - use as fertilizer - maximum site (sand).

	Ra-226 Concentrations in Phosphogypsum									
	26 pCi/g		10 pCi/g		7 pCi/g		5 pCi/g		3 pCi/g	
	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]
Agricultural Worker Direct Gamma	5.4E+00	2.2E-06	2.1E+00	8.1E-07	1.5E+00	5.7E-07	1.0E+00	4.1E-07	6.2E-01	2.5E-07
Agricultural Worker Dust Inhalation	1.1E-01	9.0E-09	4.2E-02	3.5E-09	3.0E-02	2.4E-09	2.1E-02	1.7E-09	1.3E-02	1.0E-09
On-Site Individual Direct Gamma	1.2E+01	4.6E-06	4.4E+00	1.8E-06	3.1E+00	1.3E-06	2.2E+00	8.7E-07	1.3E+00	5.2E-07
On-Site Individual Indoor Radon	---	6.8E-06	---[c]	2.6E-06	---	1.8E-06	---	1.3E-06	---	7.5E-07
On-Site Individual Well Water Use	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Inhalation of contaminated dust	6.1E-02	5.0E-09	2.3E-02	1.9E-09	1.4E-02	1.4E-09	1.2E-02	9.7E-10	7.0E-03	5.8E-10
Member of CPG - Ingestion of drinking water from contaminated well	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Ingestion of foodstuff contaminated by well water	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Ingestion of foodstuff grown on fertilized soil	8.6E-02	9.1E-09	3.3E-02	3.5E-09	2.3E-02	2.5E-09	1.6E-02	1.8E-09	9.9E-03	1.1E-09
Individual - Ingestion of river water contaminated by groundwater	---[c]	---[c]	---	---	---	---	---	---	---	---
Individual - Ingestion of river water contaminated by surface runoff	8.8E-02	7.8E-09	3.4E-02	3.0E-09	2.4E-02	2.1E-09	1.7E-02	1.5E-09	1.0E-02	9.1E-10

a. Dose or dose commitment from one year of exposure.
b. Lifetime risk from one year of exposure.
c. No radionuclides are calculated to reach the on-site well via the groundwater pathway for about 4,000 years, or the off-site river or well for more than 100,000 years because of groundwater velocities and retardation factors.

Table 4-10. Risk assessment results for Scenario 5 - use as sediment control (clay).

	Ra-226 Concentrations in Phosphogypsum									
	26 pCi/g		10 pCi/g		7 pCi/g		5 pCi/g		3 pCi/g	
	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]
Agricultural Worker Direct Gamma	1.6E+01	6.4E-06	6.3E+00	2.5E-06	4.4E+00	1.8E-06	3.2E+00	1.3E-06	1.9E+00	7.3E-07
Agricultural Worker Dust Inhalation	8.1E-01	6.6E-08	3.1E-01	2.5E-08	2.2E-01	1.8E-08	1.6E-01	1.3E-08	9.3E-02	7.6E-09
On-Site Individual Direct Gamma	3.5E+01	1.4E-05	1.3E+01	5.3E-06	9.4E+00	3.8E-06	6.7E+00	2.7E-06	4.0E+00	1.6E-06
On-Site Individual Indoor Radon	---	1.2E-05	---[c]	4.7E-06	---	3.3E-06	---	2.4E-06	---	1.4E-06
On-Site Individual Well Water Use	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Inhalation of contaminated dust	6.6E-03	5.4E-10	2.5E-03	2.1E-10	1.8E-03	1.5E-10	1.3E-03	1.0E-10	7.6E-04	6.2E-11
Member of CPG - Ingestion of drinking water from contaminated well	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Ingestion of foodstuff contaminated by well water	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Ingestion of foodstuff grown on fertilized soil	2.2E-01	2.3E-08	8.4E-02	9.0E-09	5.9E-02	6.3E-09	4.2E-02	4.5E-09	2.5E-02	2.7E-09
Individual - Ingestion of river water contaminated by groundwater	---[c]	---[c]	---	---	---	---	---	---	---	---
Individual - Ingestion of river water contaminated by surface runoff	1.5E-01	1.3E-08	5.8E-02	5.1E-09	4.1E-02	3.6E-09	2.9E-02	2.6E-09	1.8E-02	1.5E-09

a. Dose or dose commitment from one year of exposure.
b. Lifetime risk from one year of exposure.
c. No radionuclides are calculated to reach the on-site well via the groundwater pathway for almost 10,000 years, or the off-site river or well for more than 100,000 years because of groundwater velocities and retardation factors.

Table 4-11. Risk assessment results for Scenario 6 - use as sediment control (sand).

	Ra-226 Concentrations in Phosphogypsum									
	26 pCi/g		10 pCi/g		7 pCi/g		5 pCi/g		3 pCi/g	
	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]
Agricultural Worker Direct Gamma	1.6E+01	6.4E-06	6.3E+00	2.5E-06	4.4E+00	1.8E-06	3.2E+00	1.3E-06	1.9E+00	7.3E-07
Agricultural Worker Dust Inhalation	8.1E-01	6.6E-08	3.1E-01	2.5E-08	2.2E-01	1.8E-08	1.6E-01	1.3E-08	9.3E-02	7.6E-09
On-Site Individual Direct Gamma	3.5E+01	1.4E-05	1.3E+01	5.3E-06	9.4E+00	3.8E-06	6.7E+00	2.7E-06	4.0E+00	1.6E-06
On-Site Individual Indoor Radon	---	1.2E-05	---[c]	4.7E-06	---	3.3E-06	---	2.4E-06	---	1.4E-06
On-Site Individual Well Water Use	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Inhalation of contaminated dust	4.5E-01	3.7E-08	1.7E-01	1.4E-08	1.2E-01	9.9E-09	8.7E-02	7.1E-09	5.2E-02	4.3E-09
Member of CPG - Ingestion of drinking water from contaminated well	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Ingestion of foodstuff contaminated by well water	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Ingestion of foodstuff grown on fertilized soil	2.2E-01	2.3E-08	8.4E-02	9.0E-09	5.9E-02	6.3E-09	4.2E-02	4.5E-09	2.5E-02	2.7E-09
Individual - Ingestion of river water contaminated by groundwater	---[c]	---[c]	---	---	---	---	---	---	---	---
Individual - Ingestion of river water contaminated by surface runoff	1.5E-01	1.3E-08	5.8E-02	5.1E-09	4.1E-02	3.6E-09	2.9E-02	2.6E-09	1.8E-02	1.5E-09

a. Dose or dose commitment from one year of exposure.
b. Lifetime risk from one year of exposure.
c. No radionuclides are calculated to reach the on-site well via the groundwater pathway for about 4,000 years, or the off-site river or well for more than 100,000 years because of groundwater velocities and retardation factors.

Table 4-12. Risk assessment results for Scenario 7 - radon exposure risks to the on-site individual as a function of phosphogypsum application rate and Ra-226 concentration.[a]

Application Rate (lbs/Acre)	Ra-226 Concentration in Phosphogypsum (pCi/g)						
	3	7	15	20	30	45	60
500	1.0E-07	2.4E-07	5.1E-07	6.8E-07	1.0E-06	1.6E-06	2.1E-06
1,000	2.1E-07	4.8E-07	1.0E-06	1.4E-06	2.1E-06	3.1E-06	--
1,500	3.1E-07	7.5E-07	1.6E-06	2.1E-06	3.1E-06	--	--
2,500	5.1E-07	1.2E-06	2.6E-06	3.4E-06	--	--	--
5,000	1.0E-06	2.4E-06	5.1E-06	--	--	--	--
10,000	2.1E-06	4.8E-06	1.0E-05	--	--	--	--

[a] Lifetime risk from one year of exposure.

Table 4-13. Risk assessment results for Scenario 7 - external gamma risks to the on-site individual as a function of phosphogypsum application rate and Ra-226 concentration.[a]

Application Rate (lbs/Acre)	Ra-226 Concentration in Phosphogypsum (pCi/g)						
	3	7	15	20	30	45	60
500	1.1E-07	2.6E-07	5.7E-07	7.5E-07	1.1E-06	1.7E-06	2.3E-06
1,000	2.3E-07	5.3E-07	1.1E-06	1.5E-06	2.3E-06	3.4E-06	--
1,500	3.4E-07	7.9E-07	1.7E-06	2.3E-06	3.4E-06	--	--
2,500	5.7E-07	1.3E-06	2.8E-06	3.8E-06	--	--	--
5,000	1.1E-06	2.6E-06	5.7E-06	--	--	--	--
10,000	2.3E-06	5.3E-06	1.1E-05	--	--	--	--

[a] Lifetime risk from one year of exposure.

Table 4-14. Risk assessment results for Scenario 7 - Total risks to the on-site individual as a function of phosphogypsum application rate and Ra-226 concentration.[a,b]

Application Rate (lbs/Acre)	Ra-226 Concentration in Phosphogypsum (pCi/g)						
	3	7	15	20	30	45	60
500	2.2E-07	5.1E-07	1.1E-06	1.4E-06	2.2E-06	3.3E-06	4.4E-06
1,000	4.4E-07	1.0E-06	2.2E-06	2.9E-06	4.4E-06	6.5E-06	--
1,500	6.5E-07	1.4E-06	3.3E-06	4.4E-06	6.5E-06	--	--
2,500	1.1E-06	2.5E-06	5.4E-06	7.2E-06	--	--	--
5,000	2.2E-06	5.1E-06	1.1E-05	--	--	--	--
10,000	4.4E-06	1.0E-05	2.2E-05	--	--	--	--

(a) Lifetime risk from one year of exposure.

(b) The sum of the risks from Tables 4-12 and 4-13.

For each of the agricultural scenarios, the highest doses and risks result from external gamma exposure and from indoor radon inhalation to the on-site individual. For Scenario 1, the lifetime risk to the on-site individual from one year of external gamma exposure is estimated to range from 3.0×10^{-6} for 26 pCi/g phosphogypsum to 3.4×10^{-7} for 3 pCi/g phosphogypsum. The lifetime risk from one year of indoor radon inhalation is estimated to range from 2.6×10^{-6} for 26 pCi/g phosphogypsum to 3.0×10^{-7} for 3 pCi/g phosphogypsum.

For Scenario 3, the lifetime risk to the on-site individual from one year of external gamma exposure is estimated to range from 4.6×10^{-6} for 26 pCi/g phosphogypsum to 5.2×10^{-7} for 3 pCi/g phosphogypsum. The lifetime risk from one year of indoor radon inhalation is estimated to range from 6.8×10^{-6} for 26 pCi/g phosphogypsum to 7.5×10^{-7} for 3 pCi/g phosphogypsum.

For Scenario 5, the lifetime risk to the on-site individual from one year of external gamma exposure is estimated to range from 1.4×10^{-5} for 26 pCi/g phosphogypsum to 1.6×10^{-6} for 3 pCi/g phosphogypsum. The lifetime risk from one year of indoor radon inhalation is estimated to range from 1.2×10^{-5} for 26 pCi/g phosphogypsum to 1.4×10^{-6} for 3 pCi/g phosphogypsum.

The results of the first four scenarios prompted Scenario 7; an evaluation of the risks associated with the two principal exposure pathways, radon and direct gamma exposures, with varying phosphogypsum application rates and Ra-226 concentrations. Combinations of application rates and Ra-226 concentrations varied from 500 to 10,000 lbs/acre and 3 to 60 pCi/g, respectively. The affect of these two variables on the estimated risk is best illustrated by the family of curves represented in Figures 4-2 to 4-4, which illustrate the increase in risk as the Ra-226 concentrations increase with each application rate. The risks presented in the figures are those listed in Tables 4-12 to 4-14 multiplied by a 70-year exposure period. Thus, they represent the estimated lifetime risk resulting from a 70-year exposure. The total lifetime risk to the on-site individual from 70 years of external gamma and radon exposures is estimated to range from 1.5×10^{-5} for 3 pCi/g phosphogypsum applied at a rate of 500 lbs/acre to 1.5×10^{-3} for 15 pCi/g phosphogypsum applied at a rate of 10,000 lbs/acre. Using Scenario 7, the combinations of phosphogypsum application rates and Ra-226 concentrations that yield an estimated lifetime risk of 3×10^{-4} is plotted in Figure 4-5. For example, a lifetime risk of 3×10^{-4} will result when phosphogypsum, containing 1 pCi/g of Ra-226, is applied at a rate of 25,000 lbs/acre; whereas, to produce the same risk when the application rate is 1,000 lbs/acre will require a Ra-226 concentration of 30 pCi/g.

4.4.2 Phosphogypsum in Road Construction

The road construction scenarios evaluated in this risk assessment are shown schematically in Figure 4-1. The results of the risk assessment of the use of phosphogypsum in road construction are summarized in Tables 4-15 to 4-18. Estimated doses and risks for Scenarios 8 and 9, involving the use of phosphogypsum in a road base, are shown in Tables

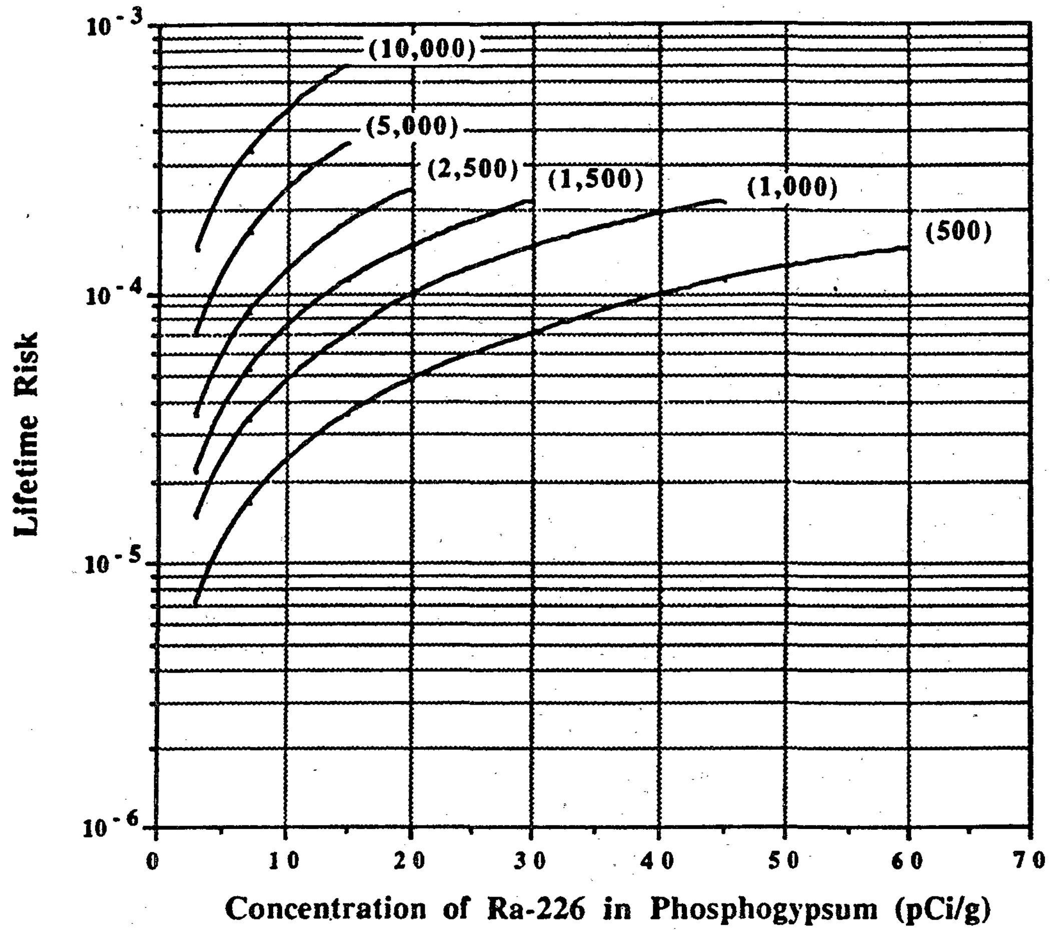


Figure 4-2. Risk assessment results for Scenario 7 - radon exposure risks to the on-site individual as a function of the Ra-226 content of phosphogypsum for the six application rates (lbs/acre) shown in parenthesis

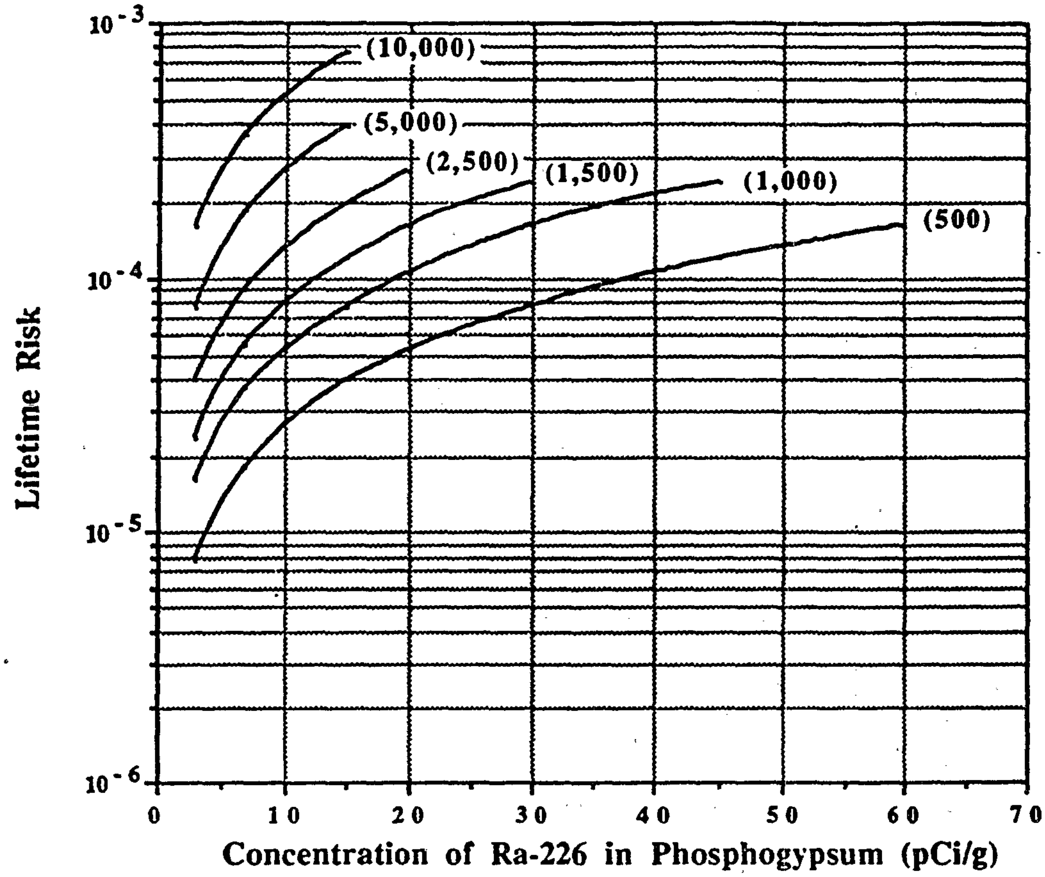


Figure 4-3. Risk assessment results for Scenario 7 - external gamma exposure risks to the on-site individual as a function of the Ra-226 content of phosphogypsum for the six application rates (lbs/acre) shown in parenthesis

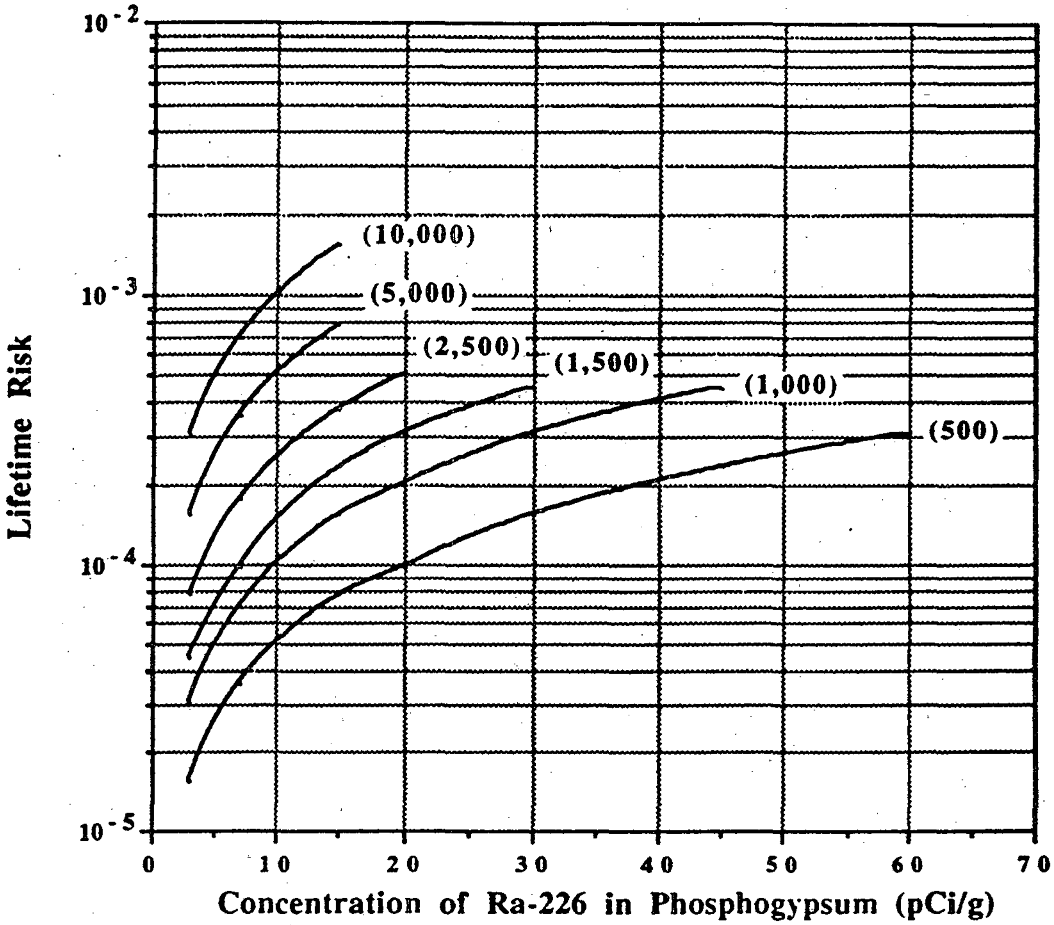


Figure 4-4. Risk assessment results for Scenario 7 - total radon and gamma exposure risks to the on-site individual as a function of the Ra-226 content of phosphogypsum for the six application rates (lbs/acre) shown in paraenthesis

Figure 4-5. Application rate of phosphogypsum as a function of Ra-226 concentration for a lifetime risk of 3×10^{-4}.

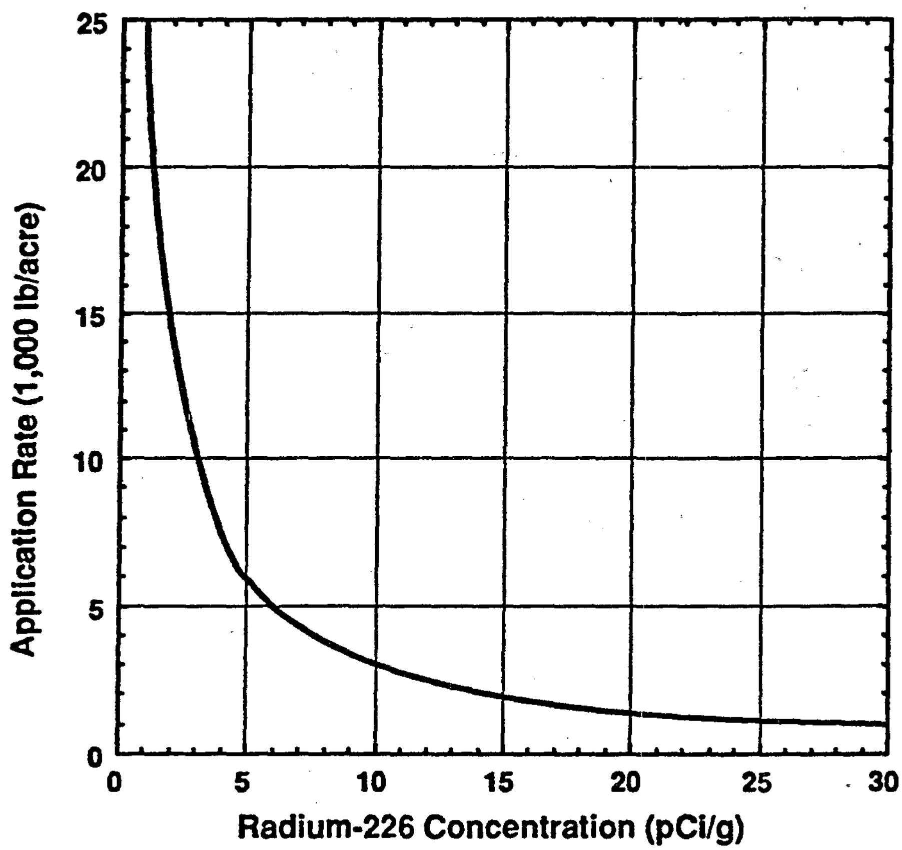


Table 4-15. Risk assessment results for Scenario 8 - use of phosphogypsum in road base for secondary road (clay).

	Ra-226 Concentrations in Phosphogypsum									
	26 pCi/g		10 pCi/g		7 pCi/g		5 pCi/g		3 pCi/g	
	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]
Construction Worker -No Shielding- Direct Gamma	4.1E+01	1.5E-05	1.6E+01	5.9E-06	1.1E+01	4.1E-06	7.9E+00	3.0E-06	4.7E+00	1.8E-06
Construction Worker -With Shielding- Direct Gamma	2.5E+01	9.0E-06	9.4E+00	3.5E-06	6.6E+00	2.5E-06	4.7E+00	1.8E-06	2.8E+00	1.1E-06
Construction Worker -Humid Site- Dust Inhalation	1.0E+00	8.4E-08	3.8E-01	3.1E-08	2.7E-01	2.2E-08	1.9E-01	1.6E-08	1.2E-01	9.4E-09
Construction Worker -Dry Site- Dust Inhalation	2.5E+00	2.2E-07	9.6E-01	8.3E-08	6.7E-01	5.8E-08	4.8E-01	4.2E-08	2.9E-01	2.5E-08
Person Driving on Road Direct Gamma	2.2E-01	8.2E-08	8.4E-02	3.1E-08	5.8E-02	2.2E-08	4.2E-02	1.5E-08	2.5E-02	9.6E-09
Member of CPG Direct Gamma	4.3E-02	1.6E-08	1.6E-02	6.2E-09	1.2E-02	4.4E-09	8.2E-03	3.2E-09	4.9E-03	1.9E-09
Member of CPG - Ingestion of Drinking Water From Contaminated Well	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Ingestion of Foodstuff Contaminated by Well Water	---[c]	---[c]	---	---	---	---	---	---	---	---
Reclaimer Direct Gamma	7.1E+01	2.6E-05	2.7E+01	1.0E-05	1.9E+01	7.2E-06	1.4E+01	5.3E-06	8.2E+00	3.2E-06
Reclaimer -Humid Site- Indoor Radon Inhalation	---	5.9E-05	---	2.2E-05	---	1.6E-05	---	1.1E-05	---	6.8E-06
Reclaimer -Dry Site- Indoor Radon Inhalation	---	6.2E-05	---	2.4E-05	---	1.7E-05	---	1.2E-05	---	7.5E-06
Reclaimer Well Water Use	---[c]	---[c]	---	---	---	---	---	---	---	---
Reclaimer - Ingestion of Foodstuff Grown On-Site	2.6E-01	1.5E-08	1.0E-01	5.9E-09	6.8E-02	4.2E-09	4.7E-02	3.0E-09	2.9E-02	1.8E-09
Individual - Ingestion of River Water Contaminated by Groundwater	---[c]	---[c]	---	---	---	---	---	---	---	---
Individual - Ingestion of River Water Contaminated by Surface Runoff	2.0E-02	1.5E-09	7.6E-03	5.6E-10	5.3E-03	4.0E-10	3.8E-03	2.7E-10	2.3E-03	1.7E-10

a. Dose or dose commitment from one year of exposure.
b. Lifetime risk from one year of exposure.
c. No radionuclides are calculated to reach the on-site well via the groundwater pathway for almost 10,000 years, or the off-site river or well for more than 100,000 years because of groundwater velocities and retardation factors.

Table 4-16. Risk assessment results for Scenario 9 - use of phosphogypsum in road base for secondary road (sand).

	Ra-226 Concentrations in Phosphogypsum									
	26 pCi/g		10 pCi/g		7 pCi/g		5 pCi/g		3 pCi/g	
	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]
Construction Worker -No Shielding- Direct Gamma	4.1E+01	1.5E-05	1.6E+01	5.9E-06	1.1E+01	4.1E-06	7.9E+00	3.0E-06	4.7E+00	1.8E-06
Construction Worker -With Shielding- Direct Gamma	2.5E+01	9.0E-06	9.4E+00	3.5E-06	6.6E+00	2.5E-06	4.7E+00	1.8E-06	2.8E+00	1.1E-06
Construction Worker -Humid Site- Dust Inhalation	1.0E+00	8.4E-08	3.8E-01	3.1E-08	2.7E-01	2.2E-08	1.9E-01	1.6E-08	1.2E-01	9.4E-09
Construction Worker -Dry Site- Dust Inhalation	2.5E+00	2.2E-07	9.6E-01	8.3E-08	6.7E-01	5.8E-08	4.8E-01	4.2E-08	2.9E-01	2.5E-08
Person Driving on Road Direct Gamma	2.2E-01	8.2E-08	8.4E-02	3.1E-08	5.8E-02	2.2E-08	4.2E-02	1.5E-08	2.5E-02	9.6E-09
Member of CPG Direct Gamma	4.3E-02	1.6E-08	1.6E-02	6.2E-09	1.2E-02	4.4E-09	8.2E-03	3.2E-09	4.9E-03	1.9E-09
Member of CPG - Ingestion of Drinking Water From Contaminated Well	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Ingestion of Foodstuff Contaminated by Well Water	---[c]	---[c]	---	---	---	---	---	---	---	---
Reclaimer Direct Gamma	7.1E+01	2.6E-05	2.7E+01	1.0E-05	1.9E+01	7.2E-06	1.4E+01	5.3E-06	8.2E+00	3.2E-06
Reclaimer -Humid Site- Indoor Radon Inhalation	---	5.9E-05	---	2.2E-05	---	1.6E-05	---	1.1E-05	---	6.8E-06
Reclaimer -Dry Site- Indoor Radon Inhalation	---	6.2E-05	---	2.4E-05	---	1.7E-05	---	1.2E-05	---	7.5E-06
Reclaimer Well Water Use	4.2E-03	4.2E-10	1.6E-03	1.6E-10	1.1E-03	1.1E-10	8.1E-04	8.0E-11	4.8E-04	4.8E-11
Reclaimer - Ingestion of Foodstuff Grown On-Site	2.6E-01	1.5E-08	1.0E-01	5.9E-09	6.8E-02	4.2E-09	4.7E-02	3.0E-09	2.9E-02	1.8E-09
Individual - Ingestion of River Water Contaminated by Groundwater	---[c]	---[c]	---	---	---	---	---	---	---	---
Individual - Ingestion of River Water Contaminated by Surface Runoff	2.0E-02	1.5E-09	7.6E-03	5.6E-10	5.3E-03	4.0E-10	3.8E-03	2.7E-10	2.3E-03	1.7E-10

a. Dose or dose commitment from one year of exposure.
b. Lifetime risk from one year of exposure.
c. No radionuclides are calculated to reach the off-site river or well via the groundwater pathway for more than 10,000 years because of groundwater velocities and retardation factors.

Table 4-17. Risk assessment results for Scenario 10 - use of phosphogypsum in a concrete road surface (clay).

	Ra-226 Concentrations in Phosphogypsum									
	26 pCi/g		10 pCi/g		7 pCi/g		5 pCi/g		3 pCi/g	
	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]
Construction Worker -No Shielding- Direct Gamma	4.1E+01	1.5E-05	1.6E+01	5.9E-06	9.1E+00	4.1E-06	7.9E+00	3.0E-06	4.7E+00	1.8E-06
Construction Worker -With Shielding- Direct Gamma	2.5E+01	9.0E-06	9.4E+00	3.5E-06	5.5E+00	2.5E-06	4.7E+00	1.8E-06	2.8E+00	1.1E-06
Construction Worker -Humid Site- Dust Inhalation	1.0E+00	8.4E-08	3.8E-01	3.1E-08	2.7E-01	2.2E-08	1.9E-01	1.6E-08	1.2E-01	9.4E-09
Construction Worker -Dry Site- Dust Inhalation	2.5E+00	2.2E-07	9.6E-01	8.3E-08	6.7E-01	5.8E-08	4.8E-01	4.2E-08	2.9E-01	2.5E-08
Person Driving on Road Direct Gamma	2.6E+00	9.6E-07	9.8E-01	3.7E-07	6.9E-01	2.6E-07	4.9E-01	1.8E-07	2.9E-01	1.1E-07
Member of CPG Direct Gamma	5.0E-01	1.8E-07	1.9E-01	7.3E-08	1.3E-01	5.1E-08	9.7E-02	3.6E-08	5.8E-02	2.2E-08
Member of CPG - Ingestion of Drinking Water From Contaminated Well	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Ingestion of Foodstuff Contaminated by Well Water	---[c]	---[c]	---	---	---	---	---	---	---	---
Reclaimer Direct Gamma	1.4E+02	5.1E-05	5.2E+01	1.9E-05	3.7E+01	1.4E-05	2.6E+01	1.0E-05	1.6E+01	5.9E-06
Reclaimer -Humid Site- Indoor Radon Inhalation	---	6.8E-05	---	2.7E-05	---	1.9E-05	---	1.4E-05	---	8.1E-06
Reclaimer -Dry Site- Indoor Radon Inhalation	---	8.1E-05	---	3.1E-05	---	2.2E-05	---	1.6E-05	---	9.3E-06
Reclaimer Well Water Use	---[c]	---[c]	---	---	---	---	---	---	---	---
Reclaimer -Ingestion of Foodstuff Grown on-Site	2.6E-01	1.5E-08	1.0E-01	5.9E-09	6.8E-02	4.2E-09	4.7E-02	3.0E-09	2.9E-02	1.8E-09
Individual -Ingestion of River Water Contaminated by Groundwater	---[c]	---[c]	---	---	---	---	---	---	---	---
Individual -Ingestion of River Water Contaminated by Surface Runoff	2.0E-02	1.5E-09	7.6E-03	5.6E-10	5.3E-03	4.0E-10	3.8E-03	2.7E-10	2.3E-03	1.7E-10

a. Dose or dose commitment from one year of exposure.
b. Lifetime risk from one year of exposure.
c. No radionuclides are calculated to reach the on-site well via the groundwater pathway for almost 10,000 years, or the off-site river or well for more than 100,000 years because of groundwater velocities and retardation factors.

Table 4-18. Risk assessment results for Scenario 11 - use of phosphogypsum in a concrete road surface (sand).

	Ra-226 Concentrations in Phosphogypsum									
	26 pCi/g		10 pCi/g		7 pCi/g		5 pCi/g		3 pCi/g	
	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]
Construction Worker -No Shielding-Direct Gamma	4.1E+01	1.5E-05	1.6E+01	5.9E-06	9.1E+00	4.1E-06	7.9E+00	3.0E-06	4.7E+00	1.8E-06
Construction Worker -With Shielding-Direct Gamma	2.5E+01	9.0E-06	9.4E+00	3.5E-06	5.5E+00	2.5E-06	4.7E+00	1.8E-06	2.8E+00	1.1E-06
Construction Worker -Humid Site-Dust Inhalation	1.0E+00	8.4E-08	3.8E-01	3.1E-08	2.7E-01	2.2E-08	1.9E-01	1.6E-08	1.2E-01	9.4E-09
Construction Worker -Dry Site-Dust Inhalation	2.5E+00	2.2E-07	9.6E-01	8.3E-08	6.7E-01	5.8E-08	4.8E-01	4.2E-08	2.9E-01	2.5E-08
Person Driving on Road Direct Gamma	2.6E+00	9.6E-07	9.8E-01	3.7E-07	6.9E-01	2.6E-07	4.9E-01	1.8E-07	2.9E-01	1.1E-07
Member of CPG Direct Gamma	5.0E-01	1.8E-07	1.9E-01	7.3E-08	1.3E-01	5.1E-08	9.7E-02	3.6E-08	5.8E-02	2.2E-08
Member of CPG - Ingestion of Drinking Water From Contaminated Well	---[c]	---[c]	---	---	---	---	---	---	---	---
Member of CPG - Ingestion of Foodstuff Contaminated by Well Water	---[c]	---[c]	---	---	---	---	---	---	---	---
Reclaimer Direct Gamma	1.4E+02	5.1E-05	5.2E+01	1.9E-05	3.7E+01	1.4E-05	2.6E+01	1.0E-05	1.6E+01	5.9E-06
Reclaimer -Humid Site-Indoor Radon Inhalation	---	6.8E-05	---	2.7E-05	---	1.9E-05	---	1.4E-05	---	8.1E-06
Reclaimer -Dry Site-Indoor Radon Inhalation	---	8.1E-05	---	3.1E-05	---	2.2E-05	---	1.6E-05	---	9.3E-06
Reclaimer Well Water Use	4.2E-03	4.2E-10	1.6E-03	1.6E-10	1.1E-03	1.1E-10	8.1E-04	8.0E-11	4.8E-04	4.8E-11
Reclaimer -Ingestion of Foodstuff Grown on-Site	2.6E-01	1.5E-08	1.0E-01	5.9E-09	6.8E-02	4.2E-09	4.7E-02	3.0E-09	2.9E-02	1.8E-09
Individual -Ingestion of River Water Contaminated by Groundwater	---[c]	---[c]	---	---	---	---	---	---	---	---
Individual -Ingestion of River Water Contaminated by Surface Runoff	2.0E-02	1.5E-09	7.6E-03	5.6E-10	5.3E-03	4.0E-10	3.8E-03	2.7E-10	2.3E-03	1.7E-10

a. Dose or dose commitment from one year of exposure.
b. Lifetime risk from one year of exposure.
c. No radionuclides are calculated to reach the off-site river or well via the groundwater pathway for more than 10,000 years because of groundwater velocities and retardation factors.

4-15 and 4-16. Estimated doses and risks for Scenarios 10 and 11, involving the use of phosphogypsum in both a concrete road surface and a road base, are shown in Tables 4-17 and 4-18.

In evaluating the risk to the construction worker from external gamma radiation, four cases were analyzed -- two in which the worker stands directly on the roadbed for the entire work day (no shielding), and two in which the worker uses equipment, such as a road grader, which provides some protection from external gamma radiation (with shielding). These four cases are considered to bracket the worker doses which could be received from external gamma radiation. Worker doses for Scenarios 8 and 9 were evaluated for the case of no asphalt cover over the roadbed to maximize the results of the dose calculations. Worker doses from dust inhalation were evaluated for a humid site (with characteristics typical of a southeastern site) and a dry site (with characteristics typical of a southwestern site).

Reclaimer doses were evaluated for a time (presumed to be 50 years after road construction) when the road is closed and the road surface has crumbled and been removed. The reclaimer is assumed to live in a house constructed on the site and to obtain 50 percent of his food from a garden grown on the site. Indoor radon doses to the reclaimer were evaluated for both a humid site and a dry site.

For the road construction scenarios, the highest doses and risks result from external gamma exposure and indoor radon inhalation to the reclaimer. For Scenarios 8 and 9, the lifetime risk to the reclaimer from one year of external gamma exposure is estimated to range from 2.6×10^{-5} for 26 pCi/g phosphogypsum to 3.2×10^{-6} for 3 pCi/g phosphogypsum. The lifetime risk from one year of indoor radon inhalation is estimated to range from 6.2×10^{-5} for 26 pCi/g phosphogypsum to 7.5×10^{-6} for 3 pCi/g phosphogypsum.

For Scenarios 10 and 11, the lifetime risk to the reclaimer from one year of external gamma exposure is estimated to range from 5.1×10^{-5} for 26 pCi/g phosphogypsum to 5.9×10^{-6} for 3 pCi/g phosphogypsum. The lifetime risk from one year of indoor radon inhalation is estimated to range from 8.1×10^{-5} for 26 pCi/g phosphogypsum to 9.3×10^{-6} for 3 pCi/g phosphogypsum.

4.4.3 Phosphogypsum in Research & Development Activities

The results of the risk assessment of the use of phosphogypsum in Research & Development activities are summarized in Table 4-19. For the Research & Development scenario (Scenario 12), a researcher is postulated to work in a laboratory and be exposed to an open 55-gallon drum of phosphogypsum. Doses to the researcher from external gamma radiation, dust inhalation, and indoor radon inhalation are evaluated.

The doses and risks to the researcher from external gamma radiation and dust inhalation are estimated to be comparable to worker doses from the agricultural and road

Table 4-19. Risk assessment results for Scenario 12 - use of phosphogypsum in R&D activities.

	Ra-226 Concentrations in Phosphogypsum									
	26 pCi/g		10 pCi/g		7 pCi/g		5 pCi/g		3 pCi/g	
	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]	Dose[a] (mrem)	Risk[b]
Researcher Direct Gamma	2.5E+00	9.1E-07	9.6E-01	3.5E-07	6.7E-01	2.5E-07	4.8E-01	1.8E-07	2.9E-01	1.1E-07
Researcher Dust Inhalation	9.1E-01	8.3E-08	3.5E-01	3.2E-08	2.5E-01	2.2E-08	1.8E-01	1.6E-08	1.1E-01	9.6E-09
Researcher Indoor Radon Inhalation	---	2.1E-05	---	8.1E-06	---	5.6E-06	---	4.0E-06	---	2.4E-06

a. Dose or dose commitment from one year of exposure.
b. Lifetime risk from one year of exposure.

construction scenarios. The greatest risk to the researcher is estimated to be from indoor radon inhalation. The indoor radon inhalation risk is estimated to range from 2.1×10^{-5} for 26 pCi/g phosphogypsum to 2.4×10^{-6} for 3 pCi/g phosphogypsum.

4.4.4 Ingestion of Treated Soil

A final risk assessment was conducted of ingesting soil that had been treated with phosphogypsum. Two scenarios are considered: Scenario 13, which assumes a biennial application rate for 100 years of 664 kg/acre of phosphogypsum containing 10 pCi/g Ra-226, and scenario 14, which assumes an initial application of 8,000 kg/acre of phosphogypsum containing 26 pCi/g Ra-226 followed by biennial applications of 4,000 kg/acre for 100 years. These application rates are the same as those used for scenarios 1/2 and 5/6, respectively (see Section 4.3.3.1). The detailed calculations and the results of this risk assessment are provided in Appendix C. The exposure periods and soil ingestion rates selected for this assessment are also listed in Appendix C.

The total estimated risks for each scenario are given in Table 4-20. The estimated risks from ingesting treated soil are small in comparison to those estimated earlier in this section for exposure to either direct gamma radiation or indoor radon-222. As might be expected, the highest estimated lifetime risk, 7.4E-6, is for a 70-year exposure period combined with using the phosphogypsum containing the highest Ra-226 concentration, 26 pCi/g. This risk is similar to that estimated for exposure to either direct gamma radiation or indoor radon when phosphogypsum containing only 3 pCi/g Ra-226 is applied at a rate of 227 kg (500 lbs) per acre (see Tables 4-12 and 4-13). Over 85 percent of the total risk is due to the presence of Pb-210 and Po-210, while the Ra-226 present contributes only about 10 percent of the risk.

Table 4-20. The estimated total risks due to the ingestion of soil treated with phosphogypsum[a].

Condition	Exposure Period[b]		
	70 year	30 year	9 year
Scenario 13	1.9E-6	8.8E-7	3.7E-7
Scenario 14	7.4E-6	3.5E-6	1.5E-6

[a] Results from Appendix C.
[b] Lifetime risk for the specified exposure period.

5. AVAILABILITY AND COSTS OF COMPETING MATERIALS

5.1 PEANUT FARMING IN GEORGIA

5.1.1 Availability

Georgia grows almost half of the peanuts produced in the United States. Of the more than 600,000 acres of peanuts grown in Georgia, approximately a third require some form of gypsum. Traditionally, 60-70% of that demand has been supplied by phosphogypsum (GDA90). But since the ban on phosphogypsum, there have been numerous entrants into the Georgia market for gypsum materials, even though there have been waivers for the agricultural use of phosphogypsum. New products in the Georgia area include: Nutcracker--a by-product of sulfuric acid neutralization distributed out of Tampa, Florida; Kemira--an industrial acid neutralization product distributed out of Savannah, Georgia; and Fluorolite--another acid neutralization product distributed out of Louisiana and Alabama. According to Agrobusiness, one of the largest distributors of gypsum materials in Georgia, these new products, as well as pure gypsum products, are abundant and available in the Georgia peanut growing area (JA91).

5.1.2 Cost

Dr. Carley, an agricultural economist at the University of Georgia, presented cost and effectiveness data for different types of gypsum fertilizers, including phosphogypsum, during public testimony on the limited reconsideration and proposed rule NESHAP for radionuclide emissions from phosphogypsum stacks in May 1990. He compared the four phosphate fertilizers in Table 5-1 with a control (no gypsum material added) to determine the economic return when using the four different types of gypsum materials. Carley found that phosphogypsum gave the highest return at $1218 per acre. U.S.G. 500, a gypsum product still available on the Georgia market today, provided a slightly lower return of $1212 per acre. The other two products analyzed, granular and pelleted substances, gave significantly lower returns.

By analyzing Dr. Carley's information, it is possible to compare the cost of increasing peanut yield from the control level for each of the gypsum materials. This comparison is shown in Table 5-2. Phosphogypsum provides the lowest cost per pound of peanuts when increasing yield. Gypsum costs are 1 cent for every pound of increased peanut yield if phosphogypsum is used as the source of gypsum. It costs four times as much, 4 cents per pound, to increase crop yield using U.S.G. 500. The two other materials, granular and pelleted substances, have considerably higher costs per pound to provide an increased yield.

Further analysis of phosphogypsum cost compared to substitutes is presented in Table 5-3. The analysis makes no assumption about comparative yield when using one gypsum fertilizer or another. It presents cost indices for gypsum materials competitive with phosphogypsum. Only two products, Fluorolite and Nutcracker have indices less than 1.

Table 5-1. Pod yields per acre of peanuts for various gypsum materials, estimated cost of various materials and estimated net return, Georgia.

Gypsum Material[a]	Experimental Yields (pds/acre)[a]	Gross Return ($/acre)[b]	Cost of Gypsum Material ($/acre)[c]	Return Minus Gypsum Cost ($/acre)
Control (no gypsum material)	2708	854	0	854
Phosphogypsum - Occiwet.	3917	1236	17.5	1218
Crystalline - U.S.G. 500	4000	1262	50	1212
Granular - Abssgram	3091	975	45	930
Pelleted - Abpellet	2768	873	37.5	835

(a) From reference A189.

(b) Priced at 1990 quota support price of $631 per ton, no adjustment made for grade.

(c) Based on Carley's personal communication with Coastal Plain Experimental Station research personnel; 1990 price quotations. Costs include transportation costs to Tift County Georgia.

Kemira is identically priced to phosphogypsum, with a cost index of 1. All of the other gypsum products are at least two and one-half times as expensive as phosphogypsum, with cost indices of 2.69 or greater. These cost indices are misleading, however, because they do not include transportation costs in the cost of the fertilizer. The two products which seem most competitive with phosphogypsum are both produced great distances from the Georgia peanut growing district -- in Tampa, Florida and Geismar, Louisiana. The Table 5-3 cost indices were revised by including estimated transportation costs from the point of sale to Tifton, Georgia for each of the fertilizers. The new cost indices are shown in Table 5-4. Tifton, Georgia was chosen as the final destination for determining transportation costs because it is in the center of the Georgia peanut growing area. The revised fertilizer cost indices show that no gypsum treatments are less expensive than phosphogypsum. Only Kemira, with a cost index of 1.28 approaches phosphogypsum. All other applications cost at least twice as much as phosphogypsum, with the exception of A.C.G.2000 and Nutcracker which cost 1.86 and 1.95 times as much as phosphogypsum, respectively.

As different soil amendments are not applied at the same rate, the application rate should be considered in the comparative pricing of different products. For example, the University of Georgia Cooperative Extension Service recommends a minimum application

Table 5-2. Gypsum material cost per pound of peanuts for competing gypsum materials.

Gypsum Material	Cost of Material ($/acre)	Experimental Yield (pds/acre)	Change in Cost From Control ($)	Change in Yield From Control (pds)	Change in Cost/Change in Yield ($/pd)
None (Control)	0	2708			
Phosphogypsum - Occiwet.	17.5	3917	17.5	1209	0.01
Crystalline - U.S.G. 500	50	4000	50	1292	0.04
Granular - Abssgram	45	3091	45	383	0.12
Pelleted - Abpellet	37.5	2768	37.5	60	0.63

Source: Table 5.1

Table 5-3. Fertilizer cost indices for competing materials relative to phosphogypsum at point of sale.

Fertilizer		Point of Sale[a]	Price at Point of Sale ($/ton)[b]	Fertilizer Cost Index
Phosphogypsum		White Springs, FL	13	1.00
U.S.G. 500		Brunswick, GA	38	2.92
Gold Bond Bag	(bagged)	Savannah, GA	41.5	3.19
	(bulk)	Savannah, GA	35	2.69
Domtar	(bagged)	Savannah, GA	47	3.62
	(bulk)	Savannah, GA	35	2.69
A.C.G. 2000		Cordele, GA	40	3.08
Nutcracker		Tampa, FL	10	0.77
Kemira		Savannah, GA	13	1.00
Fluorolite		Geismar, LA	7.5	0.58
		Columbia, AL	47	3.62
Granular (made from Kemira		Moultrie, GA	63	4.85
by Florida Favorites)		Macon, GA	63	4.85

(a) Prices obtained from a phone conversation with Jim Arnold of Agrobusiness in Albany, Georgia on August 13, 1991.

(b) The fertilizer cost does not include equipment and labor cost for applying the fertilizer or transportation costs to the farm. Equipment costs can be considered the same for all fertilizers, but labor costs are higher for the two dry gypsums, Gold Bond Bag and Domtar, than for the damp gypsums.

Table 5-4. Fertilizer cost indices for competing materials relative to phosphogypsum incorporating transportation costs into the fertilizer cost.

Fertilizer		Point of Sale	Miles From Point of Sale to Tifton, GA[a]	Transportation Cost ($/ton)[b]	Total Fertilizer Cost (Transportation & Sale) ($/ton)	Fertilizer Cost Index
Phosphogypsum		White Springs, FL	107	10.7	23.7	1.00
U.S.G. 500		Brunswick, GA	111	11.1	49.1	2.07
Gold Bond Bag	(bagged)	Savannah, GA	174	17.4	58.9	2.49
	(bulk)	Savannah, GA	174	17.4	52.4	2.21
Domtar	(bagged)	Savannah, GA	174	17.4	64.4	2.72
	(bulk)	Savannah, GA	174	17.4	52.4	2.21
A.C.G. 2000		Cordele, GA	40	4	44	1.86
Nutcracker		Tampa, FL	363	36.3	46.3	1.95
Kemira		Savannah, GA	174	17.4	30.4	1.28
Fluorolite		Geismar, LA	400	40	47.5	2.00
		Columbia, AL	107	10.7	57.7	2.43
Granular (made from Kemira		Moultrie, GA	29	2.9	65.9	2.78
by Florida Favorites)		Macon, GA	104	10.4	73.4	3.10

(a) Miles determined from a 1989 Rand McNally Road Atlas.

(b) Transportation Costs determined based on an estimated truck freight rate of $.10/ton/mile. The estimate is derived from the truck freight rate of Exhibit 2.6 of "Transportation Benefits of The Proposed Wabash Waterway," completed by Jack Faucett Associates in December of 1986. The figure was revised to account for inflation.

rate (broadcasting) for phosphogypsum and USG 500 of 1000 lbs/acre and 750 lbs/acre, respectively (USG90). Thus, a complete comparative pricing for phosphogypsum and substitute products will include their respective application rates. Table 5-5 presents the results of such an analysis for phosphogypsum and three substitute materials. It is estimated that USG 500 will cost $6.56 (about 55 percent) more per acre than phosphogypsum. Gold Bond and Kemira are 132 and 150 percent more costly per acre, respectively, than phosphogypsum.

Table 5-5. The comparison of material costs per acre.

Material	Costs (dollars/ton)		Application Rates (lbs/acre) (USG90)	Cost ($/acre)	Cost/Acre Differential ($)
	Product (Table 5-3)	Transportation (Table 5-4)			
Phosphogypsum	13	10.70	1000	11.85	0
USG500	38	11.10	750	18.41	6.56
Gold Bond	35	17.40	1050	27.51	15.66
Kemira	63	2.90	900	29.66	17.81

5.2 PEANUT FARMING IN NORTH CAROLINA

The North Carolina Agricultural Extension Service recommends that gypsum be applied to all peanuts regardless of soil type or soil nutrient levels. Although soil calcium is usually sufficient for good plant growth, it is inadequate for pod development and good quality peanuts. Application rates are balanced with the calcium content of the gypsum. Table 5-6 provides the application rates recommended by the North Carolina Agricultural Extension Service for four forms of gypsum (NC90).

According to the Department of Agriculture of the State of North Carolina, approximately two-thirds of peanut growers used phosphogypsum on crops in 1990. They estimate that the banning of phosphogypsum for agriculture use on peanuts would cost North Carolina peanut farmers approximately $2 million per year in producing 160,000 acres of peanuts (Gr90). In March 1991, the North Carolina Peanut Growers Association wrote that other gypsum sources may be available in North Carolina, but that "Phosphogypsum is less expensive, easier to handle, and convenient (Su91)." The Plant Food Association of North Carolina, which includes fertilizer manufacturers and dealers, materials suppliers, NC State University Research and Extension, and NC Department of Agriculture, wrote in April 1990, "Phosphogypsum provides a readily available and economical source of nutrients for our

Table 5-6. Gypsum sources and application rates for peanuts in North Carolina.

Source	Percent Calcium	Application Rate (lbs/acre) 16-18 in. Band	Broadcast
Bagged (finely ground)	25	600-800	--
420 Granular	25	600-800	1,200-1,600
By-Product Wet Bulk	17	--	1,800-2,300
Granular By-Product	20	750-1,000	1,500-2,000

Eastern North Carolina peanut crop. There are other sources available, but excessively expensive (Yo90)."

5.3 PEANUT FARMING IN VIRGINIA

According to S. Mason Carbaugh, Commissioner of the Commonwealth of Virginia's Department of Agriculture and Consumer Services, and his staff, "an adequate supply of gypsum is available in Virginia to meet the needs of Virginia farmers (Ca90)." Carbaugh investigated prices for substitutes and found a price of $24.30 an acre for gypsum from U.S. Gypsum and $15.75 an acre for gypsum from Materials Byproducts, Inc. Phosphogypsum, available in Virginia from Texasgulf, was comparatively priced at $15.75 an acre. All prices are FOB at a dealer warehouse. The Virginia Farm Bureau Association estimates that banning the use of phosphogypsum would cost southeast Virginia peanut farmers, who currently use phosphogypsum, $20 more an acre for an alternative. The Association estimates that this increased cost would translate into a cost of several million dollars a year for the farmers of the approximately 100,000 acres of peanuts in Virginia (As90).

5.4 AGRICULTURE IN FLORIDA

AGRO Services International, Inc., under a grant sponsored by the Florida Institute of Phosphate Research, researched the use of phosphogypsum as a fertilizer on several Florida crops (AGRO89). As part of this study, AGRO Services completed field trials using various rates and placement of phosphogypsum (holding constant the addition of other fertilizers containing nutrients not in gypsum) in order to determine the yield response of several crops to phosphogypsum. As well as determining yield response for each crop tested, AGRO determined the economic returns due to the use of phosphogypsum on the crops. By assigning a cost to phosphogypsum and its application, assigning a selling price to the tested crops, and by using the percentage yield increases of the experiment, AGRO found that only

cowpeas present a real risk in obtaining an economic return on investment in phosphogypsum among the crops tested. See Table 5-7 for a summary of the AGRO study. Application of phosphogypsum on the crops, other than cowpeas, is highly likely to result in strong economic returns, because the percentage increases in the last column of Table 5-7 are substantially higher than the break-even levels.

5.5 AGRICULTURE IN IDAHO

Simplot operates a plant in Pocatello, Idaho. In 1988 Simplot sold approximately 40,000 to 50,000 tons of phosphogypsum for use on alfalfa, onion, and potato crops in Idaho. In 1991, Simplot only sold approximately 4,500 tons of phosphogypsum for use on a ranch which produces corn, potatoes, and wheat. Due to the regulatory uncertainty surrounding the use and sale of phosphogypsum, they no longer promote sales (Mc91).

5.6 AGRICULTURE IN CALIFORNIA

According to The Fertilizer Institute, phosphogypsum is used on a variety of crops in California including citrus, almonds, vegetables, and tomatoes. The 1988 sales of phosphogypsum in California were 84,507 tons. The Fertilizer Institute estimates, however, that 1990 demand for gypsum for agricultural use in California is at 500,000-750,000 tons per year (TFI90b). Four Court, Inc., whose 1990 sales of phosphogypsum to California sources were 50,000 tons, questions the use of alternative mined gypsum from Utah. They suggest that mined gypsum from one Utah source contains high levels of uranium and thorium (Se90).

5.7 ROAD BUILDING IN FLORIDA

5.7.1 Availability

In a study considering the use of phosphogypsum for secondary road construction, the University of Miami writes, "Traditional road building materials, such as limerock, shellrock, shell, and clay are in short supply in many parts of Florida. Significant tonnages of aggregates used in road construction are now imported from foreign countries. The U.S. Bureau of Mines has forecasted that Florida will have to import all its aggregate by the year 2000 (UoM89)." The study suggests phosphogypsum as an alternative. According to the Florida Department of Transportation, however, limestone - the primary material used as a roadbase in the state of Florida - is plentiful from local sources throughout the state of Florida with a few exceptions. Natural sand-clay material and natural shellrock are also available in limited supply in some areas (He91). Thus, there appears to be differing opinions on the availability of roadbase materials in Florida, and the need for phosphogypsum in road construction is unclear.

Table 5-7. Economic returns using phosphogypsum on selected Florida crops.

Crop	Selling Price of Produce (Dollars)	Average Yield of Crop Without Phosphogypsum (pounds)	Cost of Phosphogypsum ($/acre)	Percentage Increase Needed to Break Even		Percentage Increase Found
				Using 1000 lbs/acre	Using 2000 lbs/acre	
Cantaloupe	0.10	36000	90	2.5	5	37
Sweet Corn	0.12	24000	90	3.1	6.2	55
Cow Peas	0.06	[a]	90	12.5	25	20
Bell Peppers	0.25	12000	90	1	2	40
Potatoes	0.08	60000	90	1.9	3.8	22
Tomatoes	0.14	36000	90	1.8	3.6	6
Watermelon	0.05	[a]	90	4.5	9	49

[a] Value missing from the source document.

Source: "Uses of Phosphogypsum Fortified With Other Selected Essential Elements as a Soil Amendment on Low Cation Exchange Soils." Prepared by Agro Service Intl., Inc. under a grant sponsored by the Florida Institute of Phosphate Research, Bartow, Florida, November 1989.

5.7.2 Cost

The University of Miami in conjunction with the Florida Institute of Phosphate Research constructed one and one-half miles of secondary road (Parrish Road) utilizing phosphogypsum(UoM89). They then compared the costs of building the road to the costs encountered in building two similar roads. The roads used for comparative purposes, Tanner Road and Windy Hill Road, were built in Polk County about the same time as Parrish Road, but were built with clay. The building of Parrish road was broken down into 9 tasks for which economic data (labor, capital, and energy expense) were collected. The tasks included: setting stakes and grading, hauling gypsum, spreading gypsum, boxing out and shaping up, mixing subgrade and gypsum, watering, final blade, compaction, and foreman's work. According to the analysis, the total cost for building Tanner Road and Windy Hill Road were $98,339 per mile and $129,320 per mile, respectively. In comparison, the cost of building Parrish Road was $23,485 per mile. Figure 5-1 breaks these costs down by vehicle, material, and labor costs. The road built with phosphogypsum materials has no material costs as the road was built close to the source of the phosphogypsum and the phosphogypsum was donated to the project. In order for the cost of building Parrish Road to equal the cost of Tanner Road and Windy Hill Road, the amount of phosphogypsum necessary to build one mile of road and the transportation of that amount of material would have to cost $74,854 and $105,835, respectively.

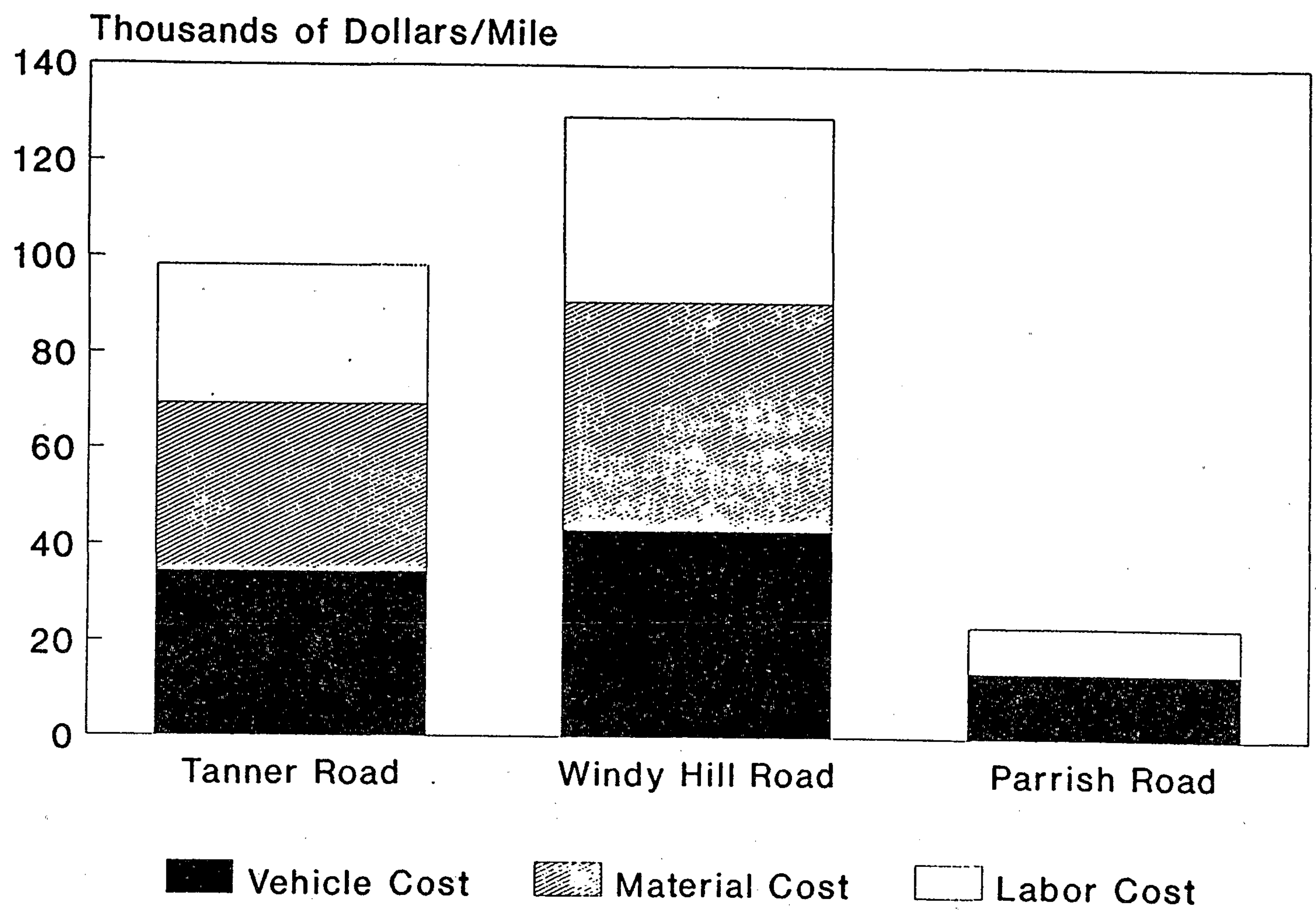
It is possible to estimate the cost of phosphogypsum to construct one mile of roadway using information provided in the BID; however, it is difficult to estimate the transportation costs. Because the transportation cost is a function of the haulage distance, it is possible, however, to estimate the distance phosphogypsum can be transported and not exceed the cost of using conventional materials ($74,854 and $105,835). The following information was provided earlier in this document.

- Roadbed Dimensions (Figure 4-1) - 0.25 m thick x 9.15 m wide x 1613 m long
- Roadbed Material Density (Table 4-5) - 2250 kg/m^3
- Cost of Phosphogypsum (Table 5-3) - $13.00/ton
- Transportation Cost (Table 5-4) - $0.10/ton-mile

Using this information, one mile of roadbed will contain 3690 m^3 of material weighing 9,151 tons. Phosphogypsum is usually mixed in various ratios with soil (clay/sand) in roadbed preparation. The amounts of phosphogypsum required and its cost for three commonly used mixtures are:

Phosphogypsum: Soil Mixture	Amount (tons)	Cost ($)
1:2	3,050	39,650
1:1	4,576	59,488
2:1	6,101	79,313

Fig. 5-1. Road building cost comparison-
traditional material vs. phosphogypsum.



Source: UoM89

Thus, the amount of money for transportation costs not to exceed the cost of Tanner ($74,854) and Windy Hill ($105,835) roads will be:

Phosphogypsum: Soil Mixture	Tanner Road ($)	Windy Hill Road ($)
1:2	35,204	66,185
1:1	15,366	46,347
2:1	-4,459	26,522

The distance phosphogypsum could be shipped and not exceed the cost of using conventional materials is presented in Table 5-8.

Table 5-8. Estimated maximum distances phosphogypsum can be hauled for road use and remain competitive with conventional materials.

Phosphogypsum: Soil Mixture	Tanner Road (miles)[(a)]	Windy Hill Road(miles)[(a)]
1:2	115	217
1:1	34	101
2:1	0	43

(a) miles = Trans. dollars available ÷ tons required x $ 0.10/ton-mile.

From this analysis, the economical advantage of using phosphogypsum in roadbed construction is not conclusive, but will depend in great part on the transportation costs. Therefore, the viability of using phosphogypsum in road construction will be dependent upon the location of the phosphogypsum in relation to the road construction site and the availability, cost, and location of competing materials.

5.8 RECLAIMING MINED LAND

5.8.1 Availability

Texasgulf produces phosphogypsum as a by-product at its wet phosphoric acid producing plant in Aurora, North Carolina (Pe91). The company's chemical processing facility is adjacent to their phosphate rock mine. In light of the proximity of the two sites, the company spent time and energy developing a method to mix clay, separated from the mined phosphate rock, and by-product phosphogypsum to reclaim mined land. This process, although economical for Texasgulf, may not be economical for other companies because the mines and the chemical processing plants of the other companies may not be close enough

together to make the blending process economical, and the clay recovered from the phosphate rock in other locations may not be suitable for this type of process.

5.8.2 Cost

Quantitative figures on the savings Texasgulf achieves by reclaiming mined land were not available. However, obvious savings include the cost of building and maintaining phosphogypsum stacks and clay settling ponds. Additionally, land reclaimed with the phosphogypsum/clay blend is available for use sooner than when it is reclaimed with only clay. Texasgulf estimates that land reclaimed with the phosphogypsum/clay mixture is suitable for revegetation approximately 9 months after reclamation. Alternatively, land reclaimed with only clay may take 20 plus years before it is suitable for revegetation.

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APPENDIX A

PATHRAE PATHWAY EQUATIONS

APPENDIX A
PATHRAE Pathway Equations

A.1 PROGRAM DESCRIPTION

The PATHRAE methodology models both offsite and onsite pathways through which man can come in contact with the waste. For each of the pathways, the dose from each nuclide is calculated as a function of time. These doses are then summed to give the total dose for the pathway. The dose to the CPG from all pathways is then computed, assuming the entire nuclide inventory is accessible through each pathway.

In this assessment, the PATHRAE code considered eight pathways by which radioactivity may reach humans. These pathways were:

1. Groundwater migration with discharge to a river.
2. Groundwater migration with discharge to a well.
3. Surface erosion of the cover material and subsequent contamination of surface water.
4. Food grown on the site.
5. Direct gamma exposure.
6. Inhalation of radioactive dust on site.
7. Inhalation of radon gas and radon daughters on site.
8. Inhalation of radioactive particulates offsite (dust resuspension).

A.2 PATHWAY EQUATIONS

The equations used to calculate the doses, D, for each of the eight pathways are presented in this section. References are given to aid the reader in understanding the assumptions on which the equations are based and, where appropriate, some discussion is given of the important features of the equations. In general, the equations can be grouped into three components representing the waste form or release rate, the transport pathway, and environmental uptake. For simplicity, the results of the environmental foodchain analysis are represented in the equations by the symbol, U, called the equivalent uptake factor.

A.2.1 Pathway One - Groundwater to a River

Groundwater migration with discharge to a river is calculated from the following equation:

$$D = \frac{Q \lambda_L f_o U_1 (DF)}{q_w} \qquad \textbf{(A-1)}$$

where

Q = inventory of the isotope available in a given year (pCi)

q_w = flow rate of the river (m^3/yr)

f_o = fraction of inventory arriving at the river from transport through the aquifer

λ_L = fraction of each nuclide leached from the inventory in a year (l/yr)

U_1 = annual equivalent uptake by an individual (m^3/yr)

DF = dose conversion factor (mrem/pCi)

The components of the equation are:

Release Rate = $Q \lambda_L$
Transport Pathway = f_o
Environmental Uptake = U_1 / q_w (DF)

The term f_o can be calculated for dispersive groundwater transport using two methods. For the first case, a constant fraction leach model is used to obtain a non-dispersion solution, which is modified by the Hung Correction Factor[4] to obtain a dispersion solution form for f_o given by:

$$f_o = 0 \qquad \text{for } t \leq t_1 - t_0$$

$$f_o = \frac{v_a F_h}{LR\lambda_L} \left[1 - \exp[-\lambda_L (t - (t_1 - t_0))]\right] \text{ for } t_1 - t_0 < t < t_1 \qquad \textbf{(A-2)}$$

$$f_o = \frac{v_a F_h}{LR\lambda_L} \exp[-\lambda_L (t - t_1)] \left[1 - \exp(-\lambda_L t_0)\right] \text{ for } t_1 \leq t$$

where

t = time (yr)

t_0 = RL/v_a

t_1 = $R(L+x_w)/v_a$

R = retardation factor = $1 + (\rho/p)k_d$

k_d = sorption coefficient in the aquifer (m^3/kg)

ρ = aquifer density (kg/m^3)

F_h = correction factor for dispersion

λ_L = length of waste site in direction parallel to aquifer flow (m)

v_a = interstitial horizontal aquifer velocity (m/yr)

x_w = distance of groundwater flow for nearest edge of burial pits to the river (m)

p = aquifer porosity.

The term F_h is strictly applicable to a time integration of the release and is given by:[4]

$$F_h = \exp\left[\frac{(L+0.5x_w)}{2D_a}\left(v_a + 2u - \sqrt{4uv_a + v_a2}\right)\right], \qquad \text{(A-3)}$$

where

D_a = longitudinal dispersivity (m)

u = $R\lambda D_a$

For dispersive groundwater transport a band release leaching model is used and f_o is given by:[5]

$$f_o = \frac{1}{N}\sum_{j=1}^{N}\left[F_j(t) - F_j(t-1/\lambda_L)\right] \qquad \text{(A-4)}$$

where

$F_j(t)$ = 0.5 U(t) [erfc (z-) + $\exp(d_j)$ erfc (z+)]

U(t) = unit step function

$z\pm$ = $\dfrac{\sqrt{d_j}\left[1+t/(Rt_{wj})\right]}{2\sqrt{t/(Rt_{wj})}}$

d_j = distance from sector center to access location, divided by the dispersity

t_{wj} = water travel time from sector center to access location (yr)

N = number of mesh points in numerical integration.

The numerical integration referred to above is a means by which the point source analytical solution for dispersive transport can be extended to approximate an area source. The

disposal facility of length L is divided into N sectors of equal length. A point source of the appropriate magnitude is placed at the center of each sector. The distance, d_{jh}, is proportional to the distance from the center of sector j to the access location. The point source analytical solutions are then summed over all sectors to approximate an area source.

A.2.2 Pathway Two - Groundwater to a Well

Groundwater migration with discharge to a well is calculated from:

$$D = \frac{Q\lambda_L f_o U_2 (DF)}{q_w} \tag{A-5}$$

The aquifer dilution water flow rate q_w is given, in this case, by:

$$Q_w = \begin{cases} WLP \text{ for } H_w > L_p \\ WL_p V_a p \text{ for } H_w < L_p \end{cases} \tag{A-6}$$

where

W	=	width of waste pit perpendicular to aquifer flow (m)
L	=	length of waste pit parallel to aquifer flow (m)
P	=	water percolation rate (m^3/m^2-yr)
L_p	=	length of well casing in aquifer (m)
H_w	=	vertical dimension of contaminated zone in aquifer (m)
v_a	=	horizontal velocity of aquifer (m/yr)
p	=	aquifer porosity
U_2	=	annual equivalent total uptake of well water by an individual (m^3/yr).

The vertical dimension of the contaminated zone, H_w, is related to the other parameters as follows:

$$H_w = \frac{P\ L}{p\ v_a}$$

A well that intercepts the contaminated zone of the aquifer may also draw in uncontaminated water if the length of the well casing, L_p, exceeds H_w. This is why Equation A-6 gives two forms for the dilution rate based on the relative magnitudes of H_w and L_p. In the general use

of PATHRAE, the factor U_2 differs from U_1 in that contaminated seafood is not included.

In addition to modeling the effects of longitudinal dispersion in the aquifer, the well pathway can account for any transverse dispersion that may occur. This reduces the conservatism when calculating nuclide doses for the well pathway. When modeling transverse dispersion, the term f_o in Equation 2-5 is modified by an additional multiplicative term, f_t, given by:

$$F_t = \frac{1}{2}\,\mathrm{erf}\,\frac{(y_w + W/2)R}{2\sqrt{D_y\,t}} - \frac{1}{2}\,\mathrm{erf}\,\frac{(Y_w - W/2)R}{2\sqrt{D_y\,t}} \qquad \textbf{(A-7)}$$

where

y_w = distance to well from center of water area in the direction perpendicular to the aquifer flow (m)

D_y = transverse dispersion coefficient (m^2/yr).

For the limiting case in which D_y goes to zero, f_t, becomes equal to one. Therefore, the effects of transverse dispersion can be ignored by choosing D_y equal to zero.

The groundwater pathways to the (river and the well) can also accommodate transport in the vertical unsaturated zone between the waste and the aquifer. This is accomplished in the same manner as in the PRESTO codes.[2,4] The vertical water velocity and retardation are given by:

$$V = P/(pS)$$

$$R = 1 + \frac{\rho}{p * s}\,k_d \qquad \textbf{(A-8)}$$

where

S = fraction of saturation.

The term S can either be input or calculated from the expression:

$$S = S_r + (1 - S_r)\left[\frac{P}{K_h}\right]^{SNO} \qquad \textbf{(A-9)}$$

where

S_r = residual saturation

SNO = soil index

K_h = vertical zone saturated hydraulic conductivity (m/yr).

A.2.3 Pathway Three - Erosion and Transport to a River

The dose for sheet erosion of cover material and waste and its subsequent deposition in a nearby river is given by:

$$D = \frac{Q f_e f_{dil} U_1 (DF)}{q_w} \tag{A-10}$$

where

f_{dil} = fraction of solids entering river that originated in waste trenches (calculated internally in the code)

f_e = fraction of waste eroded each year

q_w = river flow rate (m^3/yr).

The parameter f_e is calculated from the surface erosion rate, E_r, which is an input variable, according to the relation $f_e = E_r/t_w$, where t_w is the waste thickness (m) and E_r is expressed in m/yr.

A.2.4 Pathway Four - Food Grown Onsite

The equation for D for food grown over the disposal site is:

$$D = \frac{Q f_d f_g (DF) U_3}{V \quad s} \tag{A-11}$$

where

V = volume of waste (m^3)

ρ_s = soil density (kg/m^3)

f_d = dilution factor representing the dilution of waste in the soil

f_g = fraction of individual's diet consisting of food grown over the disposal site

U_3 = total equivalent uptake factor for food (kg/yr).

Equation A-11 assumes that at some future time a reclaimer moves onto the waste disposal site and builds a house. By excavating a basement for the house and by drilling a well on the property, some of the waste material is brought to the surface and is mixed with the

surface soil to some depth (t_g). Using these assumptions, the factor f_d representing the dilution of waste in the surface soil is given by:

$$f_d = f_m \left[\frac{t_m - t_c}{t_g \left(\frac{A_l}{A_h} - 1 \right)} + \frac{t_w}{t_g \left(\frac{A_l}{A_w} - 1 \right)} \right] \quad \textbf{(A-12)}$$

where

t_w = thickness of the waste (m)

f_m = dilution of waste in the trench before reclaimer activities occur

t_c = thickness of cover (m)

t_m = depth of maximum mechanical disturbance (m)

t_g = depth to which contaminants are mixed with surface soil (m)

A_l = lot area (m^2)

A_h = house area (m^2)

A_w = cross sectional area of wells drilled (m^2).

The first term in the brackets of Equation A-12 is the component due to the excavation of a basement. The second term is the well drilling component. A complete derivation of Equation A-12 is given in Reference 6.

A.2.5 Pathway Five - Direct Gamma

The dose from direct gamma exposure to an intruder is calculated from:

$$D = \frac{Q}{A\mu_w t_w} B(\mu_c t_c) \left[1 + \frac{3\sqrt{\pi}}{4E_\gamma} - B(\mu_{wt_w}) \exp(-\mu_{wt_w}) \right] f_{exp} \, (8760)(DFG) \quad \textbf{(A-13)}$$

where

$B(\mu t)$ = $1 + (\mu t)^{1.5}/e_\gamma$

μ_w = gamma attenuation constant of the waste (1/m)

μ_c = gamma attenuation constant of the cover (1/m)

t_w = thickness of the waste (m)

t_c = thickness of the cover (m)

$f_{(exp)}$ = fraction of the year the individual is exposed

A = plane area of the waste, the waste is assumed to be a circular horizontal plane with the exposed individual standing at the center (m^2)

E_γ = weighted average gamma energy emitted by nuclide (MeV)

DFG = infinite ground plane dose conversion factor (mrem/hr per pCi/m^2).

The function, B, in Equation A-13 is the gamma buildup factor which is used to account for the effects of gamma-ray scattering in the waste and in the cover. It is an empirical relation based on gamma scattering data at energies from 0.25 MeV to 1.0 MeV.[7]

The term in brackets in Equation A-13 accounts for self-shielding and buildup in the waste.

The weighted average gamma energy is computed by taking the average of all gamma energies emitted by a particular nuclide, each energy being weighted by its probability of occurrence.

There are three alternatives available when calculating direct gamma doses using PATHRAE. The first alternative allows the calculation of the gamma dose from the undisturbed buried waste. The second alternative assumes that plant roots penetrate the waste and transport some nuclides to the surface. Each year the plants die and deposit their absorbed nuclides on the ground surface, so there is continual transport of nuclides and deposition on the ground surface. The gamma dose is calculated from the nuclides deposited on the surface, as well as the nuclides remaining in the original burial trenches. The third alternative assumes that a reclaimer builds a house and digs a well on the site, as is described under Pathway Five. This brings some of the waste material to the surface where it is mixed with the existing soil. The gamma dose is calculated from the waste on the surface and from the waste that remains underground.

The three options in Pathway Five are selected by the value of the PATHRAE variable IGAMMA which can have the value 0, 1, or 2.

A.2.6 Pathway Six - Onsite Dust Inhalation

The dose, D, for the inhalation of resuspended dust by an inadvertent intruder is given by:

$$D = \frac{Q f_d \rho_d U_i f_{exp} (DF)}{V \rho_w} \qquad \textbf{(A-14)}$$

where

ρ_w = waste density (kg/m^3)

ρ_d = dust loading in the air breathed (kg/m^3)

f_{exp} = fraction of the year the individual is exposed to dust

U_i = volume of air breathed in a year (m^3/yr)

V = total volume of waste (m^3)

f_d = dilution factor representing the dilution of waste in the soil.

The assumptions for this pathway are similar to those for Pathway Four. That is, a reclaimer builds a house and drills a well over the waste site. The dose arises as a result of inhalation of contaminated dust during the excavation of the house's basement and the drilling of the well. As in Pathway Four, the dilution factor, f_d, is calculated using Equation A-12.

A.2.7 Pathway Seven - Inhalation of Radon in Structures

The dose from inhalation of radon and radon daughters in a structure built over the waste is calculated from:

$$D = \frac{Q}{h \lambda_r V F} E \sqrt{\lambda D_w} \tanh(100 b_w t_w) \exp(-100 b_1 t_1 - b_2 t_2) U_i (df) \qquad \textbf{(A-15)}$$

where

Q = inventory of Ra-226 (pCi)

E = fraction of radon which can emanate upward from the waste

h = height of rooms in structure built over the waste (cm)

r = air ventilation rate of the structure (air changes/sec)

V = volume of waste (m^3)

λ = decay constant of radon (1/sec)

t_w = waste thickness (m)

t_1 = thickness of earthen cover (m)

t_2 = thickness of concrete floor in reclaimer house (cm)

D_w = radon diffusion coefficient of the waste (cm^2/sec)

D_1 = radon diffusion coefficient of the cover (cm^2/sec)

D_2 = radon diffusion coefficient of concrete floor (cm^2/sec)

b_i = $\sqrt{\lambda/D_i}$ $(i = w, 1, 2)$

$$F = \frac{1}{2}\left[1 + \sqrt{a_w/a_c}\ \tanh(b_w t_w)\right] + \frac{1}{2}\left[1 - \sqrt{a_w/a_c}\ \tanh(b_w t_w)\right] \exp(-2(100\ b_1 t_1 + b_2 t_2))$$

a_i = $p_i^2\ D_i\left[1 - (1-k)\,m_i\right]^2$

m = $0.01\ M\rho/p$

M = moisture content (dry weight percent)

k = 0.26 pCi/m^3 in water per pCi/m^3 in air

p = porosity

U_i = total volume of air breathed in a year (m^3/yr).

A.2.8 Pathway Eight - Atmospheric Transport of Contaminants

The dose from the inhalation of airborne contaminants from dust resuspension (also valid for incinerator or trench fire) is given by:

$$D = \frac{Q}{V}\ r\ f_f\ f_v \left[\frac{X}{Q'}\right] U_i\ (df) \qquad \textbf{(A-16)}$$

where

r = dust resuspension rate or burn rate of incinerator or trench fire (m^3 waste/sec)

f_f = deposition velocity for dust resuspension (m/sec) or fraction of the year the burning occurs for incinerator and trench fire

f_v = nuclide-specific volatility factor for incineration or trench fire (fraction of nuclide released to atmosphere)

X = downwind atmospheric concentration (pCi/m^3)

Q´ = atmosphere source release rate (pCi/sec).

PATHRAE uses Gaussian plume[9] expressions for X/Q´:

$$\frac{X}{Q'} = \sqrt{\frac{2}{\pi}}\ \frac{f_w}{\sigma_z u}\ \frac{n}{2\pi x}\ \exp\ (-h^2/2\sigma_z^2 \tag{A-17}$$

where

f_w = fraction of time wind blows in direction of interest

σ_w = standard deviation of plume concentration in vertical direction (m)

u = average wind speed (m/sec)

n = number of sectors or wind directions (usually 16)

x = distance from source to receptor (m)

h = effective release height including momentum and thermal plume rise effects (m).

Plume depletion effects from deposition are represented by a reduced source release rate calculated internally to the code.[9]

The actual release height is modified to account for momentum and thermal plume rise effects by the following equations:[9]

$$h = h_s + \frac{1.5\ v_s\ d_s}{u} + \frac{1.6(3.7E{-}5\ x^2\ Q_H)^{0.333}}{u} \tag{A-18}$$

where

h_s = actual release height (m)

v_s = stack gas velocity (m/sec)

d_s = stack inside diameter (m)

Q_H = heat emission rate from stack (cal/sec).

Equation A-18 is valid as long as the distance to the receptor location is less than ten times the stack height. For greater distances the receptor distance, x, is replaced with 10 h_s.

If some parameters are unknown or poorly characterized, a default option, based on the location of the maximum plume concentration, is used. In this case:

$$\frac{X}{Q'} = \frac{2}{\pi h^2 e u} \qquad \textbf{(A-19)}$$

where

e = Euler's number (2.71828).

Equations A-17 and A-19 are from Reference 10 and are expressions for point sources. For the trench fire scenario it is assumed that the fire involves a relatively small amount of waste (for example, the amount received by the facility in one day). For an incinerator the only source is a single incinerator stack. Since the extent of the source is small in these cases, the use of the point source expression is justified.

If an area source is desired it can be represented by the virtual point source approximation, where x is replaced by x´, given by[1]

$$x' = x + 1.5137\ y$$

where

y = width of the facility (m)

The σ_z in Equation A-17 is calculated in PATHRAE using Briggs' approximations.[9] This necessitates specifying one of the six Pasquill atmospheric stability classes. If no stability class is specified in the input data set, the moderately stable Class D is used. The stability class should be chosen to represent an annual average stability. The wind speed, u, is the annual average wind speed in the direction from source to receptor.

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APPENDIX B

RA-226 SOIL CONCENTRATION CALCULATIONS

APPENDIX B
Ra-226 Soil Concentration Calculations

Radium-226 soil concentrations, resulting from periodic applications of phosphogypsum, can be calculated by solving a standard mass balance equation:

$$\frac{dC}{dt} = K - kC \qquad \textbf{(B-1)}$$

The solution to equation B-1 is obtained through standard differential equation solution techniques, and is found to be:

$$C = \frac{K}{k}\left(1 - e^{-kt}\right) \qquad \textbf{(B-2)}$$

Using the boundary condition of C=0 at t=0, the arbitrary constants can be solved for. The resulting solution then becomes:

$$Cs = \frac{k_i\, C_{pG}}{W} * \frac{1}{k_2 + k_3 + k_4 + k_5)} * \left(1 - e^{-(k_2 + k_3 + k_4 + k_5)t}\right) \qquad \textbf{(B-3)}$$

where

Cs	=	Ra-226 concentration in soil (pCi/g)
C_{pG}	=	Ra-226 concentration in phosphogypsum (pCi/g)
k_i	=	application rate of phosphogypsum (g/yr)
W	=	mass of soil (g)
k_2	=	Ra-226 decay rate (4.3×10^{-4} yr^{-1})
k_3	=	rate loss of Ra-226 due to uptake by plants (2.6×10^{-6} yr^{-1})
k_4	=	rate loss of Ra-226 by leaching (2.8×10^{-5} yr^{-1})
k_5	=	rate loss of Ra-226 by wind erosion (8.9×10^{-4} yr^{-1})

Using the data in the table presented below, the Ra-226 soil concentration can be calculated after 100 years of biennial phosphogypsum application.

Table B-1. Ra-226 soil concentration calculation parameters.

Parameter	Scenario 1 & 2	Scenario 3 & 4	Scenario 5 & 6
k_2 (yr^{-1})	4.3E-04	4.3E-04	4.3E-04
k_3 (yr^{-1})	2.6E-06	2.6E-06	2.6E-06
k_4 (yr^{-1})	2.8E-05	2.8E-05	2.8E-05
k_5 (yr^{-1})	8.9E-04	8.9E-04	8.9E-04
k_i (g/yr)	4.6E+07	1.0E+09	1.1E+09
t (yrs)	100	100	100
W (g)	1.9E+11	2.8E+12	1.0E+12
CpL (pCi/g)	30	30	30

A summary of the Ra-226 soil concentrations calculated for scenarios 1-6 is presented in Table B-2.

Table B-2. Ra-226 soil concentrations.

Scenario	Ra-226 Concentration (pCi/g)
1 & 2 (Agriculture: Average Case	0.69
3 & 4 (Agriculture: Maximum Case)	1.02
5 & 6 (Soil Amendment)	3.12

APPENDIX C

RISK ASSESSMENT FOR THE INGESTION OF TREATED SOIL

APPENDIX C
Risk Assessment for the Ingestion of Treated Soil

The risks that result from the direct ingestion of treated soil has been estimated using the following information:

1. Exhibit 6-14 of the Superfund Risk Assessment Guidance handbook
   a. Ingestion Rate
      - 200 mg/d 1-6 yrs of age
      - 100 mg/d 6-70 yrs of age
      - 365 days/yr

   b. Exposure Periods
      - 70 yrs - lifetime
      - 30 yrs - 90 percentile residency
      - 9 yrs - national average residency

   c. Total Uptake

      9 Year Exposure

$$(200 \text{ mg/d})(365 \text{ d/y})(6 \text{ y})+(100 \text{ mg/d})(365 \text{ d/y})(3 \text{ y})= x \text{ mg}$$
$$438{,}000 \text{ mg} + 109{,}500 \text{ mg} = x \text{ mg}$$
$$547{,}500 \text{ mg} = x \text{ mg}$$
$$547.5 \text{ g}$$

      30 Year Exposure

$$(200 \text{ mg/d})(365 \text{ d/y})(6 \text{ y})+(100 \text{ mg/d})(365 \text{ d/y})(24 \text{ y})= x \text{ mg}$$
$$438{,}000 \text{ mg} + 876{,}000 \text{ mg} = x \text{ mg}$$
$$1{,}314{,}000 \text{ mg} = x \text{ mg}$$
$$1{,}314 \text{ g}$$

      70 Year Exposure

$$(200 \text{ mg/d})(365 \text{ d/y})(6 \text{ y})+(100 \text{ mg/d})(365 \text{ d/y})(64 \text{ y})= x \text{ mg}$$
$$438{,}000 \text{ mg} + 2{,}336{,}000 \text{ mg} = x \text{ mg}$$
$$2{,}774{,}000 \text{ mg} = x \text{ mg}$$
$$2{,}774 \text{ g}$$

Table C.1. Scenario 13 - Based on 10 pCi Ra-226/g of phosphogypsum applied at the rate of 664 kg/acre biennially for 100 years.

Nuclide	Relative[1] Concentration (pCi/g soil)	RF[2] (Risk/uCi)	70 YR Risk	30 YR Risk	9 YR Risk
Ra-226	0.69	9.4 E-5	1.8 E-7	8.5 E-8	3.6 E-8
Po-210	0.66	1.4 E-4	2.6 E-7	1.2 E-7	5.1 E-8
Pb-210	0.89	5.5 E-4	1.4 E-6	6.4 E-7	2.7 E-7
Th-228	0.09	1.3 E-5	3.3 E-9	1.5 E-9	6.4E-10
Ra-228	0.09	7.0 E-5	1.8 E-8	8.3 E-9	3.5 E-9
Th-230	0.12	2.3 E-5	7.7 E-9	3.6 E-9	1.5 E-9
Th-232	0.08	2.1 E-5	4.7 E-9	2.2 E-9	9.2E-10
U-234	0.08	7.5 E-5	1.7 E-8	7.9 E-9	3.3 E-9
U-235	0.003	7.3 E-5	6.1E-10	2.9E-10	1.2 E-10
U-238	0.07	7.4 E-5	1.4 E-8	6.8 E-9	2.8 E-9
TOTAL RISK			1.9 E-6	8.8 E-7	3.7 E-7

1 Soil concentrations after 100 years of application taking into consideration removal mechanisms.

2 Risk factors from Table A-5 of EPA89b.

Table C.2. Scenario 14 - Based on 26 pCi Ra-226/g of phosphogypsum applied at the rate of 8,000 Kg/acre initial application followed by biennial applications of 4,000 Kg/acre for 100 years.

Nuclide	Relative[1] Concentration (pCi/g soil)	RF[2] (Risk/uCi)	70 YR Risk	30 YR Risk	9 YR Risk
Ra-226	2.74	9.4 E-5	7.1 E-7	3.4 E-7	1.4 E-7
Po-210	2.64	1.4 E-4	1.0 E-6	4.8 E-7	2.0 E-7
Pb-210	3.55	5.5 E-4	5.4 E-6	2.6 E-6	1.1 E-6
Th-228	0.34	1.3 E-5	1.2 E-8	5.8 E-9	2.4 E-9
Ra-228	0.34	7.0 E-5	6.6 E-8	3.1 E-8	1.3 E-8
Th-230	0.47	2.3 E-5	3.0 E-8	1.4 E-8	6.0 E-9
Th-232	0.31	2.1 E-5	1.8 E-8	8.8 E-9	3.6 E-9
U-234	0.30	7.5 E-5	6.3 E-8	3.0 E-8	1.2 E-8
U-235	0.013	7.3 E-5	2.6 E-9	1.2 E-9	5.0 E-10
U-238	0.28	7.4 E-5	5.7 E-8	2.7 E-8	1.1 E-8
TOTAL RISK			7.4 E-6	3.5 E-6	1.5 E-6

1 Soil concentrations after 100 years of application taking into consideration removal mechanisms.

2 Risk factors from Table A-5 of EPA89b.